HAMAKUA AREA AGRICULTURAL WATER STUDY

MAIN REPORT

Prepared By:
UNITED STATES DEPARTMENT OF AGRICULTURE
Economic Research Service
Forest Service
Soil Conservation Service

In Cooperation With:
STATE OF HAWAII
Department of Land and Natural Resources
Mauna Kea Soil and Water Conservation District

Honolulu, Hawaii

March, 1982

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MAIN REPORT /#c

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DEPARTMENT OF LAND AND NATURAL RESOURCES
MAUNA KEA SOIL AND WATER CONSERVATION DISTRICT.

HONOLULU, HAWAII

MARCH 1982

TABLE OF CONTENTS

TABLE OF CONTENTS (Contd.)

TABLES

TABLE OF CONTENTS (Contd.)

Page

FIGURES

PREFACE

The Hamakua Area Agricultural Water Study (HAAWS) was undertaken in response to the people's concern for a reliable and adequate supply of agricultural water for the Hamakua area, and for opportunities to improve its use for the greater benefit to all. Concerns were also expressed for the land and the desire to adopt measures that better assure a lasting resource base for agriculture and other interests. In general, the purpose of HAAWS was to address these concerns by studying the problems and resources of the area, and developing alternative plans to solve the problems.

This Main Report describes the study findings and displays plans which, if implemented, would improve the supply and distribution of agricultural water and the land it serves. A Preferred Plan is displayed. In addition to this report, nine special reports* were prepared. Six reports detail the investigations of special land and water resources or describe the economic, social, and environmental features of the study area. The other three reports were developed as part of the planning process.

HAAWS is a Cooperative River Basin Study made under the authority of Section 6, Public Law 83-566, the Watershed Protection and Flood Prevention Act. The study was conducted by the U.S. Department of Agriculture (USDA), in cooperation with local sponsors. The study followed USDA planning procedures for application of the Water Resources Council's Principles and Standards for Water and Related Land Resources Planning (18 CFR Part 711).

USDA responsibilities in the study were fulfilled by the USDA Field Advisory Committee (FAC) composed of the Economic Research Service (ERS), Forest Service (FS), and Soil Conservation Service (SCS). The committee directed the overall management and administered the study, with SCS as lead agency.

The local sponsors of the study were the Mauna Kea Soil and Water Conservation District (SWCD) and the State of Hawaii, Department of Land and Natural Resources (DLNR). Two special committees were also formed to assure public input and to help guide the study. The two committees were the HAAWS Citizens Advisory Committee and the HAAWS Steering Committee.

The Citizens Advisory Committee was responsible for providing public input, providing information to and receiving input from the general public, and surveying public attitudes towards the study. The committee also had the opportunity to comment on this report and the special study reports.

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*See Appendix B for a description of the reports.

The Citizens Advisory Committee was made up of representatives from the following organizations or agricultural sectors:

Davies Hamakua Sugar Company
Farmers
Hamakua Development Council
Independent Sugarcane Growers
Mauna Kea Soil and Water Conservation District
Parker Ranch
Ranchers

The Steering Committee was responsible for providing information that would be beneficial to the study, participating in the development of alternative plans and the selection of a Preferred Plan, and guiding the study to accomplish its purpose. The committee also had the opportunity to review and comment on this report and the special study reports. The Steering Committee was composed of representatives from the following organizations:

Federal

Economic Research Service
Forest Service
Soil Conservation Service

State

College of Tropical Agriculture and Human Resources, University of Hawaii
Department of Agriculture
Department of Hawaiian Home Lands
Department of Land and Natural Resources
Mauna Kea Soil and Water Conservation District

County

Department of Research and Development
Department of Water Supply

Private

Hawaii Chapter Conservation Council for Hawaii
Theo. H. Davies and Company, Ltd.

ACKNOWLEDGEMENTS

The Hamakua Area Agricultural Water Study (HAAWS) has involved numberous federal, state, and county agencies; private organizations, and local residents of the study area. The United States Department of Agriculture, as preparer of this report, acknowledges these groups for their help and cooperation, without which the study could not have been conducted. The Department especially acknowledges the contributions of the individual members of the Mauna Kea Soil and Water Conservation District, the HAAWS Citizens Advisory Committee, and the HAAWS Steering Committee.

SUMMARY

The Hamakua Area Agricultural Water Study (HAAWS) was conducted by the U.S. Department of Agriculture (USDA) in cooperation with the Mauna Kea Soil and Water Conservation District (SWCD) and the State of Hawaii, Department of Land and Natural Resources (DLNR), study sponsors. The study had the following principal objectives:

1. Identify the agricultural water and related land resource problems and concerns.

2. Inventory the study area's resource base.

3. Develop and evaluate alternative plans for alleviating the agricultural water and related land resource problems.

4. Select a Preferred Plan.

5. Identify technical and financial assistance opportunities through federal, state, and local agencies for implementation of the Preferred Plan.

DESCRIPTION OF THE STUDY AREA

The study area is 211,660 acres in size and is located in the northern part of the Island of Hawaii (Fig. 1). Agriculture is the major industry in this rural area. Sugarcane is grown on 35,720 acres along the Hamakua coastline from elevations near sea level up to 2,000 feet. Above the sugarcane fields are 22,740 acres of forest and 122,620 acres of pasture lands. About 1,400 acres of land in the study area has been developed for the production of truck crops such as lettuce, cabbage, and celery. About 560 acres are presently cultivated or irrigated at any one time. The major truck crop producing areas are located in Waimea. There are also small macadamia nut orchards scattered throughout the study area which total 1,190 acres.

Waimea, the major population center in the study area, is a rural farming and ranching community. Other population centers include sugarcane plantation towns, such as Honokaa, Paauilo, and Ookala.

PROBLEMS AND CONCERNS

The sponsors identified two major problems for study. The first major problem was the inadequate distribution and supply of agricultural water. Agricultural production in the study area is adversely affected and limited by both the supply and distribution of agricultural water.

FIGURE 1

LOCATION AND LAND USE MAP

HAMAKUA AREA AGRICULTURAL WATER STUDY

HAWAII

DECEMBER 1981

10 0 10 20 MILES

SCALE 1:500,000

Source:
Base map prepared by SCS, WTSC Carto Unit from AMS 1:250,000 series.
Thematic detail compiled by state staff.

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M7-L-24154

Present agricultural water systems are unable to meet the irrigation and stockwater needs of farmers and ranchers. These systems are unreliable because they are unable to store enough water for drought periods. Past droughts have resulted in crop and livestock production losses of over 25 percent. The inadequate water storage capacities of these systems also limit the acres of truck crops and sugarcane that can presently be irrigated. In addition, future expansion of irrigated crop areas will be limited unless more agricultural water storage is made available.

Many areas are not serviced by an agricultural water system. Farmers and ranchers in these areas must rely on other more expensive sources of water, such as the domestic water system. Some ranchers must pump or haul stockwater from the domestic lines up to their pastures located at higher elevations.

The second major problem was the inadequate protection of land and related water resources in the study area. Unprotected crop and pasture lands are susceptible to soil erosion by wind and rain. Erosion adversely affects soil fertility and thus crop yields. Sediment from eroding land causes damages to crops and fields and affects water quality.

The study also addressed other concerns dealing with the maintenance of minimum streamflows, future hydropower development, and the potential to increase the storage capacities of the proposed agricultural water systems.

PREFERRED PLAN

The Preferred Plan, selected by the public and sponsors, represents the preferred alternative for possible implementation. The plan entails improving the Lalamilo Irrigation System to irrigate 821 acres of truck crops and 176 acres of hay, and to provide stockwater for use on 40,924 acres of pasture. The plan also includes land treatment measures to control erosion for areas serviced by the improved water system.

OPPORTUNITIES FOR IMPLEMENTATION

Technical and financial assistance for implementing elements of the Preferred Plan can be obtained through various federal and state agencies or programs. Several USDA programs offer possible sources of federal assistance. These programs include the Watershed Protection and Flood Prevention Act, as amended (Public Law 566), Resource Conservation and Development Program, Soil Conservation Act of 1935 (Public Law 46), Agricultural Conservation Program, and Farmers Home Administration loan program.

DLNR's Division of Water and Land Development (DOWALD) has the authority, as the state water resources and development agency, to install elements

of the Preferred Plan with funds appropriated by the state legislature. The state Department of Agriculture administers an Agricultural Loan Program which provides funds to supplement private and federal funds or to make direct loans to farmers.

ALTERNATIVE PLANS

In addition to the Preferred Plan, three alternative plans were developed: the National Economic Development Plan, the Environmental Quality Plan, and the Primarily Nonstructural Plan. These three plans were prepared in compliance with USDA planning policy, 502.20 National Basin and Area Planning Manual.

The National Economic Development Plan, formulated to reasonably maximize net benefits to national economic development, entails improving the Lalamilo Irrigation System to provide water to irrigate 821 acres of truck crops and to provide stockwater for use on 40,924 acres of pasture. The plan also includes land treatment measures necessary for agricultural production on the additional acres of irrigated cropland brought into production by the plan.

The Environmental Quality Plan, formulated to reasonably maximize net contributions to environmental quality, entails providing land treatment to control erosion and to adequately protect the land and related water resources in the study area. The plan also includes some improvements to the Lalamilo Irrigation System that would benefit the environment.

The Primarily Nonstructural Plan, formulated to emphasize the minimum use of structural measures, entails rehabilitating the Lalamilo Irrigation System to provide water to irrigate 668 acres of truck crops. The plan also includes land treatment for areas serviced by the improved water system.

These alternative plans, along with the Preferred Plan, are summarized in Table 1.

TABLE 1
SUMMARY OF ALTERNATIVE PLANS
Hamakua Area Agricultural Water Study

	National Economic Development Plan	Environmental Quality Plan	Primarily Nonstructural Plan	Preferred Plan
I. ACRES SERVICED BY AGRICULTURAL WATER SYSTEM				
A. Cropland Provided Irrigation Water				
1. Truck Crops	821	250	668	821
2. Hay	0	0	0	176
B. Pasture Provided Stockwater	40,924	0	0	40,924
TOTAL ACRES	41,745	250	668	41,921
II. ACRES BENEFITED BY ASSOCIATED LAND TREATMENT				
A. Truck Crops	316	0	163	316
B. Pasture	0	0	0	0
C. Hay	0	0	0	176
TOTAL ACRES	316	0	163	492
III. ACRES BENEFITED BY ACCELERATED LAND TREATMENT				
A. Truck Crops	0	120	264	417
B. Sugarcane	0	18,520	0	0
C. Pasture	0	9,620	0	3,213
D. Hay	0	0	0	176
TOTAL ACRES	0	28,260	264	3,806
IV. BENEFITS (Annual)[1/]	$ 2,248,300	$ 100,000	$ 473,700	$ 2,232,300
V. COSTS[2/]				
A. Total	$16,152,200	$1,289,500	$4,090,200	$21,362,800
B. Annual	1,340,900	107,300	359,500	1,760,100
VI. NET BENEFITS (Annual)	$ 907,400	$ 7,300	$ 114,200	$ 472,200
VII. BENEFIT/COST RATIO[3/]	1.68:1	.93:1	1.32:1	1.27:1

1/ Land treatment benefits not evaluated.
2/ Accelerated land treatment costs not included.
3/ Annual benefits divided by annual costs.

CHAPTER I
PROBLEMS AND CONCERNS

The problems and concerns of the study were initially identified by the Mauna Kea SWCD and DLNR, sponsors of the study. Several meetings were held with the local people and the sponsors to refine and select the problems and concerns that they would like the study to address. The selected problems included:

1. The inadequate distribution and supply of agricultural water.

2. The inadequate protection of land and related water resources from erosion and sedimentation.

These problems are described in more detail under Present Conditions and are projected to the year 2000 under Future Without Conditions.

PRESENT CONDITIONS

Agricultural Water Problems

The major agricultural industries in the study area are truck crops, sugarcane, and livestock production. The inadequate distribution and supply of agricultural water affects production in all of these industries.

Truck Crops

For the purposes of this study, truck crops were defined to include vegetable crops, as well as nursery crops such as flowers and ornamental plants. Truck crop operations are concentrated in the Lalamilo, Puukapu, and Hawaiian Home Lands farmlots in Waimea. Waimea is one of the major vegetable producing areas in the state. The climate and fertile soils in Waimea, along with irrigation, are ideal for growing crops such as lettuce, cabbage, and celery.

Small, scattered farms located in the Ahualoa, Kalopa, and Honokaa areas produce crops such as cucumbers and tomatoes. Waipio Valley is one of the major taro producing areas in the state with about 30 acres in production.

Irrigation water for truck crops is supplied by two main sources, the state's Lalamilo Irrigation System and the county's Department of Water Supply Waimea Water System (Fig. I-1). The Lalamilo Irrigation System provides water to the existing 670-acre Lalamilo farmlots area. The farmlots are divided into about 28 units. Approximately 230 acres are under sprinkler irrigation. Brought into operation in 1961 to service the farmlots, the system is operated and maintained by DOWALD.

Vegetable crop being sprinkler irrigated on a typical Lalamilo farm.

The Upper Hamakua Ditch (UHD) collects and transports water from five streams in the Kohala Mountains to the Lalamilo Irrigation System. The streams include the Kawainui, Kawaiki, Alakahi, Koiawe, and Waima. The UHD, beginning at elevation 4,042 feet, is a series of lined and unlined ditches, flumes and tunnels. Intake structures at each stream divert water into the UHD. Constructed in the early part of this century, the ditch was originally used to transport water to the sugarcane fields on the Hamakua Coast. It has been damaged by rainstorms and natural deterioration, is in constant need of repair, and suffers transmission losses throughout.

A 24-inch pipeline transports water from an intake structure at the UHD, elevation 3,035 feet, to the 60-million-gallon (MG) Waimea Reservoir. Water is then transported through recently installed pressurized pipelines to the farmlots. Installed were 19,350 feet of 24-inch ductile iron pipe (DIP) and 10,500 feet of 18-inch DIP to replace a leaky concrete main, thereby cutting transmission losses. In addition, the 4.5-MG Lalamilo Reservoir provides temporary storage for emergency situations.

Figure 1-1

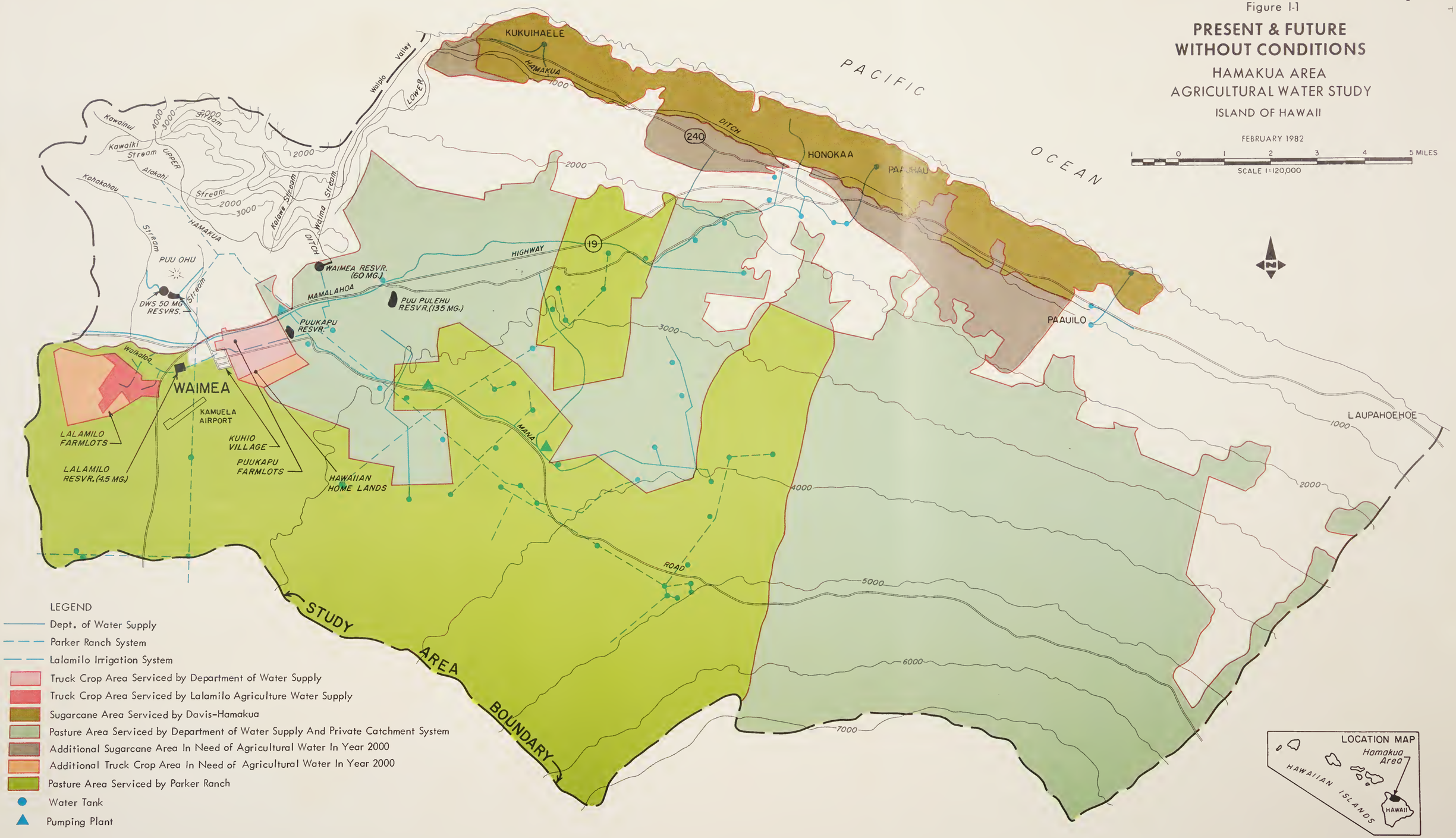
PRESENT & FUTURE WITHOUT CONDITIONS

HAMAKUA AREA AGRICULTURAL WATER STUDY

ISLAND OF HAWAII

FEBRUARY 1982

SCALE 1:120,000



LEGEND

- Dept. of Water Supply
- Parker Ranch System
- Lalamilo Irrigation System
- Truck Crop Area Serviced by Department of Water Supply
- Truck Crop Area Serviced by Lalamilo Agriculture Water Supply
- Sugarcane Area Serviced by Davis-Hamakua
- Pasture Area Serviced by Department of Water Supply And Private Catchment System
- Additional Sugarcane Area In Need of Agricultural Water In Year 2000
- Additional Truck Crop Area In Need of Agricultural Water In Year 2000
- Pasture Area Serviced by Parker Ranch
- Water Tank
- Pumping Plant

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Upper Hamakua Ditch wooden flume section.

There have been five major droughts in the study area within the past 15 years. Lalamilo farmers were put on restricted irrigation schedules during these drought periods because the system did not have enough storage to provide a full water supply. A recent drought caused yields to drop by as much as 25 percent and many farmers were forced to delay the planting of new crops. Crop losses were estimated at $500,000 (sales value).

The limited storage capacity of the Lalamilo Irrigation System also restricts further expansion of truck crop production in the Lalamilo area. The development of the proposed 340-acre state Lalamilo Agricultural Park - Phase I is doubtful, unless additional water storage is provided. The park would be divided into 22 lots of various sizes and would have an estimated 163 acres under irrigation. Potential production from the park is estimated to have an annual sales value of $1.3 million.

The Waimea Water System is managed by the County Department of Water Supply (DWS). This domestic system provides quality potable water for the study area. There are about 300 acres of irrigated truck crops in the Puukapu, Hawaiian Home Lands, Ahualoa, Kalopa, and Honokaa areas. Because the farmers in these areas do not have a source of agricultural water, they must depend on the domestic system to irrigate their crops. The cost of domestic water is much higher than the cost of agricultural water from the Lalamilo Irrigation System. Domestic water costs anywhere from 45 to 65 cents per 1,000 gallons, plus each user is assessed a monthly service meter charge. Agricultural water costs 7 to 8 cents per 1,000 gallons, plus $2.25 per acre serviced per month. The monthly water bill, including any service charges, for an average size truck crop farm using domestic water would be about $230; whereas, the water bill would be about $60 if the farm used agricultural water.

The sources of water for the domestic system are the Kohakohau and Waikoloa streams. The system has five reservoirs within the Waimea area with a total storage capacity of 112.5 MG. The flow from the two source streams varies greatly with weather changes.

The farmers and the Department of Hawaiian Home Lands (HHL) have expressed a desire to continue expanding truck farming and to make better use of the present farmlots in these areas. Of the 76 farmlots in the Puukapu and HHL areas, only 39 are presently used to grow truck crops. The remaining farmlots are either idle or are used for pasture. The soil in these farmlots have been identified as being well suited for truck crop production. This was determined by an intensive soil survey of the Waimea area conducted by SCS and is contained in the HAAWS Land Resource Report.*

However, any future expansion in these areas will be difficult without additional water in view of the increasing competition for an already limited supply of domestic water. Homeowners and farmers alike have also been put on restricted use schedules during drought periods.

Sugarcane

Of the 35,720 acres of sugarcane in the study area, 32,000 acres are operated by the Davies Hamakua Sugar Company and 3,720 acres are operated by 165 independent growers. At the present time, 6,895 acres of Davies sugarcane are sprinkler or drip irrigated. None of the independent growers irrigate their sugarcane and are solely dependent on rainfall.

The Hawaii Irrigation Company, a private water system owned and operated by Davies, supplies both industrial and irrigation water for the sugar company. The Lower Hamakua Ditch (LHD), a series of lined and unlined

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*See Appendix B for a description of the report.

Young sugarcane irrigated by efficient drip system.

ditches, flumes, and tunnels, serves as the main collection and distribution line. The ditch begins at Kawainui Stream (elevation 1,037 feet), snakes through Waipio Valley, continues along the Hamakua Coast and ends in Paauilo (Fig. I-1). A series of small reservoirs along the LHD provides water storage for only about a day's use.

The system is presently limited by the amount of water available in the LHD during periods of low rainfall and the lack of adequate storage reservoirs. The system is unable to supply the total water requirements of the area presently irrigated. Yields in these areas are not at an optimum level. Davies has an average water deficit of 2,984 MG per year; and the deficit is very acute during drought periods.

Additional acres of Davies sugarcane would benefit from irrigation if more water were available. The entire 3,720 acres of sugarcane operated by the independent growers would also benefit from irrigation. Yields for sugarcane have gone up by as much as 3 to 4 tons of sugar per acre (TSA), from 9 TSA to 12-13 TSA, when irrigation water was applied to previously nonirrigated sugarcane. Sugarcane has extremely high water requirements, prohibiting the use of domestic water for irrigation because of the high cost.

Stockwater

Presently, there are approximately 122,620 acres of pasture along the Hamakua Coast and in the Waimea area. Parker Ranch, by far the largest ranch in the state, encompasses 226,400 acres, 65,750 acres of which are in the study area. There are about 150 smaller ranches located in the Kukaiau, Laupahoehoe, Ahualoa, Kalopa, Nienie, Paauilo, and Waimea areas.

Livestock production is limited by both the supply and distribution of stockwater in the study area. Water for stockwater use comes from three main sources: the Parker Ranch system, the Waimea Water System, and the small water catchment-storage systems located on individual ranches (Fig. I-1).

The Parker Ranch system provides stockwater to the ranch pastures located in the Waimea area. This system is old and deteriorated, and unable to supply the total stockwater needs of the ranch. Catchment-storage systems are used to supply stockwater on pastures located on the slopes of Mauna Kea. The ranch management has also expressed a need for water to grow irrigated hay, most likely alfalfa, for livestock feed.

All other ranchers depend on the Waimea Water System or catchment-storage systems for their supply of stockwater. Added to the already high cost of domestic water is the cost of having to pump or haul the water up from the domestic lines to pastures located at much higher elevations. The labor to operate and maintain the pumps is another added cost. Ranchers must depend on catchment-storage systems to supply stockwater in areas where pumping or hauling costs are prohibitive. These systems often run dry during drought periods and cattle must then be moved to other areas. The ranchers are thus restricted from efficient use of all their pastures.

Stockwater catchment-storage system.

Land and Related Water Resource Problems

Another major problem in the study area is the inadequate protection of land and related water resources. Land unprotected from the elements of wind and rain are susceptible to erosion. Soil erosion occurs mainly on cropland and can adversely affect soil fertility or cause damage to fields. Sediment carried in the runoff from eroding land causes water quality problems.

Land is considered to be adequately protected when the rate of soil erosion is equal to or less than the rate of soil formation. The present situation regarding agricultural land use and the areas adequately protected or in need of treatment is shown in Table I-1. The following sections will describe the land and related water resource problems in the areas considered inadequately protected.

TABLE I-1
STATUS OF AGRICULTURAL LANDS
Present Conditions
Hamakua Area Agricultural Water Study

Land Use	Total Acres	Land Adequately Protected	Land Needing Treatment
Truck Crops			
Irrigated.....	560	360	200
Sugarcane			
Dryland.....	28,825	5,800	23,025
Irrigated.....	6,895	2,000	4,895
SUBTOTAL.....	35,720	7,800	27,920
Pasture[1/]			
Zone 1.....	34,000	17,900	16,100
Zone 2.....	38,000	30,400	7,600
Zone 3.....	50,620	40,500	10,120
SUBTOTAL.....	122,620	88,800	33,820
TOTAL.....	158,900	96,960	61,940

1/

Zone	Annual Rainfall (inches)	Elevation (feet)
1	20-40	2,000-2,500
2	40-60	2,500-4,000
3	60+	4,000+

Truck Crops

In general, truck crop lands do not have significant water erosion problems. This is due primarily to the small field sizes, gentle slopes, and the low annual rainfall typical in the truck farming areas. Land preparation techniques such as disk harrowing, plowing, and leveling destroy soil structure and remove vegetative cover, thereby increasing soil susceptibility to water and wind erosion. Soil erosion can adversely affect soil fertility and water-holding capacity, and thus crop yields. Wind can also cause high evaporation losses during irrigation.

Erosion on exposed sugarcane field.

Sugarcane

At the present time, nearly eighty percent of the sugarcane land has erosion rates that exceed the rate of soil formation and are in need of land treatment measures. Movement of soil occurs in sugarcane land primarily during the period between harvesting and the development of a full canopy. It takes 5 to 6 months before the cane is large enough to form a canopy that protects the soil. Soil loss is estimated at 7.0 to 13.5 tons per acre per year or 0.05 to 0.10 inches per year. A ton of soil has a volume of 1 to 2 cubic yards.

In these exposed sugarcane fields, erosion results in soil being moved downslope. This soil movement can adversely affect soil fertility, structure, and water-holding capacity. Erosion can also damage in-field roads used to transport cane. Gullies formed on seriously eroding roads must be smoothed over so cane trucks can pass. Runoff from the unprotected fields also deposits sediment on roads and in roadside ditches. Much of the sediment is carried down waterways and into the ocean. This results in water pollution problems and sediment damage to marine life.

Dry pasture shows evidence of erosion near water tank.

Pasture

The pasture land can be divided into three distinct grazing management and forage production zones (Table I-1). Annual rainfall and elevation are the primary determining factors in establishing these zones.

At the present time, 88,800 acres out of the total 122,620 acres of pasture are adequately protected. The remaining 33,820 acres suffer from erosion problems which are more apparent in the low rainfall areas. Erosion in these areas is primarily due to the sparse vegetation, lack of adequate watering facilities, and inadequate fencing.

FUTURE WITHOUT CONDITIONS

Agricultural Water Problems

Future Without (FWO) Conditions are present conditions projected to the year 2000. FWO Conditions describe the problems and concerns in the future if nothing is done to solve them. Agricultural production would continue to be limited by the inadequate distribution and supply of agricultural water.

Truck Crops

The area in irrigated truck crops is expected to increase from 560 to 600 acres. This would mainly be due to increased irrigation efficiencies. The truck farming areas are expected to remain the same and irrigation water would be supplied by the same two sources, the Lalamilo Irrigation System and the Waimea Water System.

The Lalamilo Irrigation System would continue to serve only the Lalamilo farmlots area if no major improvements are made to the system. The operation and maintenance costs for the system are expected to increase as the aged UHD continues to deteriorate. Lalamilo farmers would continue to experience production losses from recurring droughts.

The Puukapu, Hawaiian Home Lands, Ahualoa, Kalopa, and Honokaa truck farmers would continue to use domestic water from the Waimea Water System to irrigate their crops. Truck crop production would not be able to reach its fullest potential in these areas because of limited supply and high cost of domestic water.

Sugarcane

The acres of sugarcane are expected to remain relatively stable. The irrigation conversion plan as proposed by the Davies Hamakua Sugar Company is expected to be implemented. The plan would result in 7,959 acres of drip- and sprinkler-irrigated sugarcane. None of the acres operated by the independent growers are expected to be irrigated.

The Davies irrigation system would continue to be limited by the amount of water available in the LHD during periods of low rainfall and lack of storage reservoirs. Davies is expected to have a water deficit of 2,223 MG per year. However, the ongoing program of conversion from sprinkler to drip would conserve a significant amount of water while allowing more acres to be irrigated. The following table shows how Davies expects to take advantage of this water conservation opportunity.

TABLE I-2
DAVIES HAMAKUA IRRIGATION CONVERSION PLAN
Hamakua Area Agricultural Water Study

Ongoing Program	Method of Irrigation	Field Application Efficiency	Area Ac.	Annual Irr.Req. MG/Yr.	Peak Irr.Req. MGD
Existing in 1979	Overhead Sprinkler	54%	5,041	6,192	45.3
	Drip	80%	1,854	1,472	11.1
	Total		6,895	7,664	56.4
Planned Improvements	Overhead Sprinkler	54%	1,630	1,898	14.3
	Drip	80%	6,329	5,005	38.2
	Total		7,959	6,903	52.5

The planned conversion to drip irrigation results in a decrease in gross irrigation requirements by 761 million gallons, while increasing the irrigated area by 1,064 acres.

Stockwater

The acres of pasture is expected to remain relatively stable. The existing Parker Ranch System is expected to remain in service, although operation and maintenance costs would be higher. Ranches in Kukaiau, Laupahoehoe, Ahualoa, Kalopa, and Waimea would continue to use the Waimea Water System and catchment-storage facilities. Low rainfall periods would continue to pose problems for these ranches. Ranchers would also still be unable to efficiently graze all their pastures.

Land and Related Water Resource Problems

The land and related water resource problems in the study area are expected to be less severe under Future Without Conditions. Land treatment measures, applied as part of the ongoing conservation program conducted by the Mauna Kea SWCD and SCS, would increase the number of acres adequately protected. Agricultural land use and the areas adequately protected or needing treatment under Future Without Conditions are shown in Table I-3.

TABLE I-3
STATUS OF AGRICULTURAL LANDS
Future Without Conditions
Hamakua Area Agricultural Water Study

Land Use	Acres	Land Adequately Protected	Land Needing Treatment
Truck Crops			
Irrigated.....	600	480	120
Sugarcane			
Dryland.....	27,761	11,200	16,561
Irrigated.....	7,959	6,000	1,959
SUBTOTAL.....	35,720	17,200	18,520
Pasture			
Zone 1.....	34,000	29,000	5,000
Zone 2.....	38,000	36,000	2,000
Zone 3.....	50,620	48,000	2,620
SUBTOTAL.....	122,620	113,000	9,620
TOTAL.....	158,940	130,680	28,260

Truck Crops

The acres of irrigated truck crops is expected to increase from 560 to 600 acres. Approximately 480 out of the 600 acres would be adequately protected under Future Without Conditions. The remaining 120 unprotected acres will continue to suffer soil erosion that would adversely affect soil fertility and water-holding capacity.

Sugarcane

The acres of sugarcane that are adequately protected is expected to increase from 7,800 acres under Present Conditions to 17,200 acres under Future Without Conditions. However, over half of the sugarcane acreages would still need land treatment measures. Erosion in these areas would continue to deplete the soil and cause sediment problems.

Pasture

The acres of pasture that are adequately protected are projected to increase from 88,800 acres to 113,000 acres. The remaining 9,620 acres without adequate land treatment would continue to suffer from erosion problems.

OTHER CONCERNS

During the study, other concerns expressed included:

1. Maintenance of minimum streamflow.

2. Potential for future hydropower development.

3. Potential to increase the storage capacities of the proposed agricultural water systems.

Although these concerns were not quantifiable in terms of Present and Future Without Conditions, they were addressed and incorporated during the formulation of alternatives.

Maintenance of minimal flow or low flow within a stream is vital to its ecosystem. With this concern in mind, stream intake structures designed to maintain minimum streamflow were considered for possible inclusion in all of the agricultural water systems developed as part of the study.

The island of Hawaii's dependence on costly fuel-oil generated electricity makes other potential alternate sources of electricity attractive. Because it was known that the study would probably include the development of agricultural water systems with water sources high in the Kohala Mountains, the potential for hydropower development existed. It was felt that the agricultural water systems developed should be analyzed for potential future hydropower development.

Waimea is one of the most rapidly growing areas in the state. Although it was known that the study would probably include proposals to develop agricultural water systems with more water storage than is presently available, there was still concern that any proposed system could some day prove inadequate. With this concern in mind, the potential to further increase the storage capacities of the proposed systems was also analyzed.

CHAPTER II
PREFERRED PLAN

INTRODUCTION

The Preferred Plan is a result of the planning process. The plan was formulated to address the problems and concerns of the study with the available resources, and it is the preferred alternative for possible implementation.

Throughout the planning process, meetings were held with the sponsors, FAC, special committees, and the public to keep them informed on the progress of the study and to gain their input. In March 1981, several meetings were held to present and discuss elements from various proposed agricultural water systems* that were available for inclusion in the Preferred Plan (Table II-1). After evaluating the concerns of all the parties involved, the sponsors made the final determination of the priorities for providing agricultural water and the elements to be included in the Preferred Plan.

The Preferred Plan includes elements that emphasize economic development and environmental quality. The plan entails improving the agricultural water system to provide water to irrigate 821 acres of truck crops and 176 acres of hay, and for stockwater use on 40,924 acres of pasture (Fig. II-1). The plan also includes the land treatment measures necessary to adequately protect the land and related water resources from erosion and sedimentation in the areas serviced by the improved agricultural water system.

The following sections describe the elements, effects, and the capabilities of the Preferred Plan. The elements include structural and nonstructural measures to address the problems and concerns of the study.

Economic, environmental, and other social effects of the plan were evaluated. The plan was also evaluated in terms of its capability to address the problems and concerns of the study.

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*Developed as part of the planning process and contained in the special HAAWS report "Agricultural Water System Proposals." See Appendix B for a description of the report.

TABLE II-1
MARCH 1981 MEETINGS TO DISCUSS ALTERNATIVE SOLUTIONS

Date	Participants	Total No. 1/	Purpose	Pertinent Issues, Concerns, and Agreements
March 4, 1981	Sponsors, Local Citizens Advisory Committee, SCS	15	To present the agricultural water system proposals.	-Representative from the Davies Hamakua Sugar Company expressed concerns on the supply of water to Davies. Whether the division of water for the various agricultural water systems contained in the proposals would decrease the company's water supply. Flow regulating structures would allow low flows to be bypassed, thus assuring Davies of a minimum flow during periods of low rainfall. Davies water supply would not be adversely affected if these structures were installed.
March 4, 1981	Public, Sponsors, SCS	50	To present the agricultural water system proposals to the public for their consideration and to gain input for the formulation of the Preferred Plan.	-There was concern in general about the capability of the proposed reservoirs to store enough water for drought periods. Reservoirs can be sized to provide varying amounts of storage. There was general agreement that the Preferred Plan should provide adequate storage for drought periods. -There was concern that the diversion of water would adversely affect the supply of water to Waipio Valley. None of the agricultural water systems, contained in the proposals presented, would adversely affect the supply of water to Waipio Valley.
March 5, 1981	Sponsors, SCS	12	To select Preferred Plan elements.	-The sponsors listed the following priorities for providing agricultural water: 1. Truck crops. 2. Stockwater along the Hamakua Coast. 3. Irrigated hay. 4. Supplemental water for sugarcane irrigation. SCS is to develop an agricultural water system that provides water for these priority areas. The system will be part of the Preferred Plan. The sponsors also directed SCS to develop the plan to include: 1. Minimum repairs to the UHD. 2. Utilization of the existing 60-MG Waimea Reservoir. 3. Utilization of the Puu Pulehu Reservoir for storage. 4. Construction of possible reservoirs in the Kohala Mountains.

1/ Total number of participants.

Figure II-1

PREFERRED PLAN

HAMAKUA AREA AGRICULTURAL WATER STUDY

ISLAND OF HAWAII

FEBRUARY 1982

1 0 1 2 3 4 5 MILES

SCALE 1:120,000

KUKUIHAELE
HAMAKUA DITCH
PACIFIC OCEAN
HONOKAA
PAAUHAU
PAAUILO
LAUPAHOEHOE
Waiolo Valley
LOWER
Kawainui Stream
Kawaiki Stream
UPPER
Alakahi Stream
Kahakohau
Concrete Channel
PUU OHU RESVR. (145 MG.)
PUU OHU
HAMAKUA DITCH
Kolekole Stream
Waima Stream
HIGHWAY 19
WAIMEA RESVR. (60 MG.)
MAMALAHOA
PUU PULEHU RESVR. (135 MG.)
DWS 50 MG RESVRS.
21" REGULATING RESVR. (10 MG.)
PUUKAPU RESVR.
Existing 18"
Existing 24"
Walaloa
WAIMEA
KAMUELA AIRPORT
LALAMILO FARMLOTS
LALAMILO RESVR. (4.5 MG.)
KUHIO VILLAGE
PUUKAPU FARMLOTS
HAWAIIAN HOME LANDS
MANA
ROAD
STUDY AREA BOUNDARY
2000
3000
4000
5000
6000
7000
1000
6"
16"
27"
5"
4"
3.5"
2"

LEGEND
- Delivery Point
- Pump Station
- Reservoir
- Truck Crops
- Pasture
- Irrigated Hay

LOCATION MAP
Hamakua Area
HAWAIIAN ISLANDS
HAWAII

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OR 1982

7-N-24198-2

PREFERRED PLAN ELEMENTS

The major elements in the Preferred Plan are the improvement of the agricultural water system and land treatment. The components in each element are described, quantified, and located in the following narrative. The operation of the improved irrigation system under different water supply conditions is also described.

Agricultural Water System Improvements

The Preferred Plan includes improvements to the present Lalamilo Irrigation System's collection, reservoir storage, and distribution systems. The collection system includes all of the components necessary to divert stream water and transport it to the reservoirs for storage. The reservoir storage system includes the reservoirs and any components necessary to transport water between reservoirs. The distribution system includes the pipelines necessary to transport water from the reservoirs to the various outlets or areas. Table II-2 lists their components and their costs.

Collection System Improvements

Improvements to the collection system include repairing 9,640 feet of the upper reach of UHD from the Kawainui to the Alakahi Stream. The ditch would be regrouted to reduce transmission losses and its sidewalls would be increased by one foot to increase its present capacity. Three new flow regulating structures will be constructed to replace the existing intake structures at the Kawainui, Kawaiki and Alakahi streams.

An open concrete channel would be constructed to divert water from the upper reach of UHD to the proposed 145-MG reservoir at Puu Ohu* (Fig. 1I-1). The channel would be rectangular in shape, 5,500 feet long and 3.5 feet in height. Bottom width would vary from 5 to 10 feet.

No repairs would be made to the lower reach of UHD. The ditch would continue to divert water from the Waima and Koiawe streams and transport it to the Waimea Reservoir.

Reservoir Storage System Improvements

The total storage capacity of the present Lalamilo Irrigation System is 60 MG. The Preferred Plan calls for total storage to be increased to 350 MG. Besides the utilization of the existing 60-MG Waimea Reservoir, the plan includes the construction of a 145-MG and a 10-MG reservoir, and the restoration of the Puu Pulehu Reservoir to store 135 MG.

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*To be described in the following section.

The 145-MG reservoir is referred to as the Puu Ohu Reservoir in this report because it would be located adjacent to the hill named Puu Ohu (Fig. II-1). The reservoir would be a concrete lined dam and it would have a water surface area of 28 acres. It would have an emergency spillway that discharges into the Oolamakapehu Gulch.

The 10-MG reservoir is referred to as the Regulating Reservoir and it would be located above Kuhio Village (Fig. II-1). This reservoir would control the flow of water into the Waimea Reservoir. It would also be a concrete lined dam and would have a water surface area of 2 acres. It would have an emergency spillway that also discharges into the Oolamakapehu Gulch. The maximum water elevation in the Regulating Reservoir would be the same as in the Waimea Reservoir. The water level in both reservoirs would be at the same elevation under most flow conditions.

Rehabilitation of Puu Pulehu Reservoir would include the installation of a service road, principal and emergency spillways, and an inlet/outlet system. The upstream and downstream slopes of the embankment would also be repaired. The water surface area of Puu Pulehu would be 32 acres.

Water would be transported between the reservoirs by existing and proposed pipelines as shown in Figure II-2. A pumping plant with a 5,900-gallon-per-minute (gpm) capacity would also be installed at Puu Pulehu Reservoir.

The proposed 21-inch DIP, 16-inch DIP, and pumping plant are considered part of the reservoir storage system (Fig. II-2). Although the proposed 27-inch DIP would be used to transport water between reservoirs, it would also be used to distribute water to the various areas and is considered to be a part of the distribution system.

Distribution System Improvements

Truck Crops

The major improvement to the truck crops distribution system would be the installation of 5,000 feet of 27-inch pipeline. This pipeline would connect the 10-MG Regulating Reservoir to the recently installed 18- and 24-inch pipelines (Fig. II-2). Together these pipelines would convey water to the Lalamilo farmlots, the proposed Lalamilo Agricultural Park - Phase I development, and the Hawaiian Home Lands and Puukapu farmlots.

The distribution system would have the capacity to supply a peak flow of 12.6 million gallons per day (MGD) and 1,457 MG annually for 821 acres of sprinkler irrigated truck crops in these areas. The 27-inch DIP was sized to supply the irrigation requirements of both truck crops and hay. Only the pipeline cost associated with the truck crops supply is included as a truck crops distribution system cost item (Table II-2).

TABLE II-2
STRUCTURAL ELEMENTS AND COSTS - PREFERRED PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost[1/] Total	Av. Ann.[2/]	O&M[3/]	Total Av. Ann. Cost
			dollars			
AGRICULTURAL WATER SYSTEM IMPROVEMENTS						
A. COLLECTION SYSTEM						
1. UHD (Repair)	feet	9,640	1,105,000	86,500	5,500	92,000
2. Concrete Channel	feet	5,500	2,813,900	220,100	10,400	230,500
3. Flow Regulating Structures	number	3	110,500	8,700	500	9,200
TOTAL (COLLECTION SYSTEM)	-	-	4,029,400	315,300	16,400	331,700
B. RESERVOIR STORAGE SYSTEM						
1. Reservoirs						
a. Puu Ohu	MG	145	6,601,300	516,500	7,200	523,700
Crops - Truck Crops & Hay	MG	(140)[4/]	(6,370,300)	(498,400)	(6,900)	(505,300)
Stockwater	MG	(5)	(231,000)	(18,100)	(300)	(18,400)
b. Regulating	MG	10	651,900	51,000	600	51,600
c. Puu Pulehu (Rehabilitation)	MG	135	866,200	67,800	7,200	75,000
Subtotal (Reservoirs)	MG	350	8,119,400	635,300	15,000	650,300
2. Pipeline						
a. 16" DIP	feet	15,200	1,648,800	129,000	12,000	141,000
b. 21" DIP	feet	9,500	2,466,700	193,000	13,700	206,700
3. Pumping Plant	gpm	5,900	402,000	31,400	14,800[5/]	46,200
TOTAL (RESERVOIR STORAGE SYSTEM)	-	-	12,636,900	988,700	55,500	1,044,200
C. DISTRIBUTION SYSTEM						
1. Truck Crops & Hay						
a. 27" DIP	feet	5,000	1,120,500	87,600	4,800	92,400
Truck Crops	-	-	(853,100)[4/]	(66,700)	(3,900)	70,600
Hay	-	-	(267,400)	(20,900)	(900)	21,800
2. Stockwater						
a. 2-6" DIP or PVC	feet	101,500	3,370,100	263,700	12,000	275,700
TOTAL (DISTRIBUTION SYSTEM)	-	-	4,490,600	351,300	16,800	368,100
TOTAL (WATER SYSTEM IMPROVEMENTS)	-	-	21,156,900	1,655,300	88,700	1,744,000

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Figures in ( )'s not included in totals.
5/ Includes $2,800 annual replacement costs.

Stockwater

The stockwater distribution system would be connected to the proposed 21-inch DIP between the Puu Ohu and the Regulating reservoirs (Fig. II-2). A 6-inch polyvinyl chloride (PVC) pipe would run from the 21-inch DIP to elevation 3,200, change to a 6-inch DIP crossing Mamalahoa Highway, and then rise to elevation 3,200 near Mana Road (Fig. II-1). At this point, the pipeline would change to 6-inch PVC pipe again and continue down the Hamakua coastline, ending above the town of Paauilo. The diameter of the PVC pipe would decrease in stages, from 6 inches to 2 inches, as it progresses towards Paauilo.

The distribution system would have the capacity to supply a peak flow of .42 MGD and 65 MG annually for stockwater use on 40,924 acres of pasture.

Hay

An outlet in the proposed 27-inch DIP would be provided to supply irrigation water for hay use. Installation of the distribution pipeline to the hay area is not included as part of the Preferred Plan. The 27-inch DIP cost associated with the hay irrigation water supply is the only hay distribution system cost item. The system would have the capacity to supply a peak flow of 4.3 MGD and 479 MG annually for 176 acres of hay under sprinkler irrigation.

System Operation

Under the Preferred Plan, the improved agricultural water system would operate variably, according to the inflow of water and the water supply available from the various reservoirs.

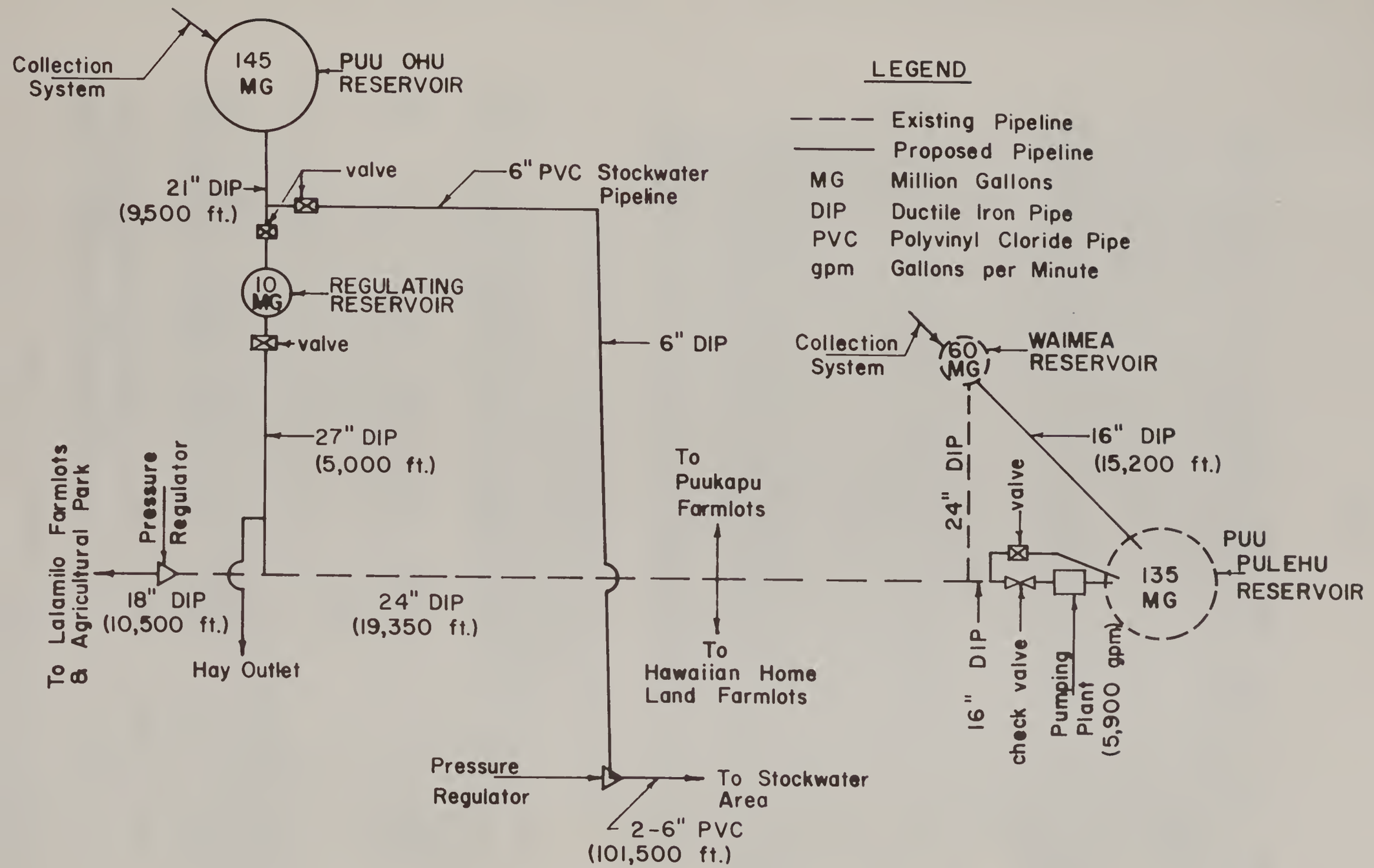
High or Normal Inflow

During high or normal inflow periods, the Puu Ohu Reservoir would serve as the primary source of water for truck crops and hay irrigation, and for stockwater use (Fig. II-2). Excess water would be stored in the other reservoirs.

The Regulating Reservoir would control the supply of water from Puu Ohu for hay irrigation, the Hawaiian Homes, Puukapu, and Lalamilo farmlots, and the proposed Lalamilo Agricultural Park - Phase I. The Regulating Reservoir would also control the flow of excess water going from Puu Ohu to the Waimea Reservoir for storage. When Waimea is at capacity, overflow would discharge through the proposed 16-inch DIP to the Puu Pulehu Reservoir.

Low Inflow

During periods of low inflow, a minimal amount of water would always be kept in Puu Ohu to supply stockwater. The Regulating Reservoir would



SCHEMATIC DIAGRAM
AGRICULTURAL WATER SYSTEM
PREFERRED PLAN

Hamakua Area Agricultural Water Study
Figure II-2

supply water for the present Lalamilo farmlots, Lalamilo Agricultural Park - Phase I, and hay. The Waimea Reservoir would be used to supply the Hawaiian Homes and the Puukapu farmlot areas.

No Inflow

Should the Regulating or Waimea Reservoir go dry, water from the Puu Pulehu Reservoir would be used. The pumping plant at Puu Pulehu would be used to pump water directly to the truck crop and/or hay area with the excess flows during pumping being used to refill the Regulating and Waimea reservoirs. The Puu Ohu Reservoir would continue to be used to supply stockwater.

Land Treatment

The Preferred Plan includes providing both the associated and accelerated land treatment for the areas serviced by the improved agricultural water system as proposed by the plan. Associated land treatment provides for those land treatment measures necessary to derive the full benefits of the structural elements included in the plan and includes any technical assistance required to plan and apply the measures. Accelerated land treatment provides for any land treatment (measures and technical assistance) that is needed over and above what would be applied as part of the ongoing conservation program and is necessary to adequately protect the land and related water resources on agricultural land.

The plan includes associated land treatment for 492 acres of cropland and accelerated land treatment that would benefit a total of 3,806 acres (Table II-3).

TABLE II-3
LAND TREATMENT - PREFERRED PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost 1/ 2/ Total	Installation Cost 1/ 2/ Av. Ann.	O&M 3/	Total Av. Ann. Cost
			dollars			
I. ASSOCIATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres 4/	316	126,400	9,900	0	9,900
2. Hay.....	acres 4/	176	70,400	5,500	0	5,500
SUBTOTAL.....	acres 4/	492	196,800	15,400	0	15,400
B. Technical Assistance...	person-years	.44	9,100	700	0	700
TOTAL (ASSOCIATED).....	-	-	205,900	16,100	0	16,100
II. ACCELERATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres 4/	417	238,200	18,600	1,700	20,300
2. Pasture.....	acres 4/	3,213	985,800	77,100	40,800	117,900
3. Hay.....	acres 4/	176	100,500	7,900	700	8,600
SUBTOTAL.....	acres 4/	3,806	1,324,500	103,600	43,200	146,800
B. Technical Assistance...	person-years	3.13	65,100	5,100	0	5,100
TOTAL (ACCELERATED).....	-	-	1,389,600	108,700	43,200	151,900

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Acres benefited.

PREFERRED PLAN EFFECTS

The following sections present an evaluation of the economic, environmental, and social effects of the Preferred Plan. The effects were measured as the differences between the forecasted conditions with the Preferred Plan, and forecasted conditions without the plan (Future Without Conditions).

The effects are organized into four accounts: national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). These four accounts encompass all significant effects on the human environment as required by the Water Resources Council, and on social well-being as required by Section 122 of the Flood Control Act of 1970. The RED account is excluded because the effects of the Preferred Plan on regional economic activity were not significant or could not be determined.

NED Account

Beneficial Effects

Beneficial NED effects are attributable to the value of the increased output of goods and services that would be generated by the Preferred Plan. The effects were measured as the increase in net income (gross income minus production costs) received by producers with the plan, compared to net income without the plan. The improved agricultural water system would increase the net income from agricultural production by:

- Providing water for an additional 163 acres of irrigated truck crops in the proposed Lalamilo Agricultural Park.

- Allowing the Puukapu and Hawaiian Home Lands farmlots to convert from the domestic to the agricultural water system. They would be able to irrigate a total of 408 acres of truck crops, which includes 255 existing acres and 153 additional acres.

- Providing water for livestock use on 40,924 acres of pasture that are using water from the domestic system, Parker Ranch system and/or catchments.

- Providing water to irrigate 176 acres of hay.

Another beneficial effect would be the reduction of operation and maintenance (O&M) costs for the Lalamilo Irrigation System due to the repair of UHD. If left as is, UHD would continue to deteriorate. DOWALD estimated that future O&M costs could be as high as $100,000 annually.

Total average NED beneficial effects are an estimated $2,232,300 (Table II-4).

Adverse Effects

Adverse NED effects are attributable to the cost of the resources that would be required to implement the Preferred Plan. Total average annual adverse effects are estimated to be $1,760,100 (Table II-4).

Net Effects

Total average annual net beneficial effects are $472,200. The benefit cost ratio is 1.27:1.

EQ Account

HAAWS "Environmental Impact Assessment," by Kennedy Engineers, identified the various natural and cultural resources within the study area. The assessment included fish habitat and wildlife habitat surveys, water quality and mineral resource assessments, recreation and visual quality of the landscape assessments, and a cultural resources inventory. Only the specific resources that would be affected by the Preferred Plan or that would have a material bearing on the decision-making process are included in the discussion of the EQ account. Table II-5 displays the beneficial and adverse environmental effects of the Preferred Plan on these specific resources. The effects are displayed in the following three categories: ecological attributes, aesthetic attributes, and cultural attributes.

It was found that there are no sites on the National Register of Historic Places which would be altered by the Preferred Plan. However, if during construction anything of historical or archeological value or any endangered plants, fish, or wildlife may be effected, work will be stopped until the problem is alleviated.

OSE Account

The effects in this account were evaluated in the following categories: urban and community impacts; long-term productivity; energy requirements and consumption; and life, health, and safety. Table II-6 displays these effects.

CAPABILITY OF THE PREFERRED PLAN

The two major problems identified for study were the inadequate distribution and supply of agricultural water and the inadequate protection of land and related water resources. Other concerns addressed during the study dealt with the maintenance of minimum flows in streams, potential hydropower development, and potential to increase storage capacity of any proposed agricultural water system.

Objectives were developed to address these problems and concerns. Tables II-7a and II-7b display the capability of the Preferred Plan to meet the objectives of the study in comparison with Future Without Conditions.

TABLE II-4
PREFERRED PLAN EFFECTS
NATIONAL ECONOMIC DEVELOPMENT ACCOUNT
Hamakua Area Agricultural Water Study

Beneficial Effects		Adverse Effects	
Components	Measure of Effects (average annual)	Components	Measure of Effects (average annual)
A. Value to users of increased outputs of goods and services:		A. Value of resources required for the plan:	
1. Irrigation - Cropland	$1,865,100 1/	1. Plan Outlays 3/	
2. Stockwater - Pasture and Livestock	267,200 1/	a. Agricultural Water System Improvements 4/	
3. Reduction in O&M 2/	100,000	(1) Irrigation - Cropland	
		Installation Cost	$1,373,500
		O&M	76,400
		(2) Stockwater - Pasture and Livestock	
		Installation Cost	281,800
		O&M	12,300
		Subtotal	$1,744,000
		b. Associated Land Treatment 5/	
		Installation Cost	16,100
		O&M	0
		c. Accelerated Land Treatment 5/	
		Installation Cost	(108,700) 6/
		O&M	(43,200) 6/
TOTAL BENEFICIAL EFFECTS	$2,232,300	TOTAL ADVERSE EFFECTS	$1,760,100
NET BENEFICIAL EFFECTS 7/	472,200		
BENEFIT/COST RATIO 8/ = 1.27:1			

1/ Price base is 1981 current normalized.
2/ Reduction in operation and maintenance costs.
3/ Amortized at 7 5/8% interest for 50 years.
4/ From Table II-2.
5/ From Table II-3.
6/ Accelerated land treatment costs are not charged against NED beneficial effects.
7/ Total beneficial effects minus total adverse effects.
8/ Total beneficial effects divided by total adverse effects.

TABLE II-5
PREFERRED PLAN EFFECTS
ENVIRONMENTAL QUALITY ACCOUNT
Hamakua Area Agricultural Water Study

Beneficial Effects		Adverse Effects	
Components	Measures of Effects	Components	Measures of Effects
A. Ecological Attributes	1. Flow regulating structures will improve the habitat of aquatic species by diverting less water (1.3 cfs[1/]) from the Kawainui, Kawaiki, and Alakahi streams.	A. Ecological Attributes	1. Loss of 34 acres of upland wildlife habitat due to the construction of two reservoirs and a concrete channel.
	2. Land treatment measures to control erosion will improve the habitat of aquatic species in streams and in the ocean by reducing sedimentation.		
B. Aesthetic	1. The additional 316 acres of irrigated truck crops and 176 acres of irrigated hay will add more color contrast on the landscape.	B. Aesthetic Attributes	1. Temporary unsightly landscape during the construction of plan elements.
	2. Rehabilitation will improve the appearance of Puu Pulehu Reservoir and the surrounding area.		2. Temporary disruption of the rural environment during the construction of plan elements.
	3. Construction of the Puu Ohu and Regulating reservoirs will create an additional 30 acres of surface water. The additional water surface will add to the diversity of the landscape and provide potential habitat for water birds.		
C. Cultural Attributes	1. Identifies archeological and historical sites	C. Cultural Attributes	1. Unknown archeological sites may be disturbed during construction.

1/ Cubic feet per second.

TABLE II-6
PREFERRED PLAN EFFECTS
OTHER SOCIAL EFFECTS ACCOUNT
Hamakua Area Agricultural Water Study

Beneficial Effects		Adverse Effects	
Components	Measures of Effects	Components	Measures of Effects
A. Urban and Community Impacts	1. Creates 165 new jobs in agriculture.	A. Urban and Community Impacts	None
	2. Provides an additional 3.57 person-years of on-farm technical assistance to farmers and ranchers to plan and apply land treatment measures.		
	3. The improved water system will provide a source of agricultural water for an additional 152 small farm and ranch units (including 48 native Hawaiian units.)		
	4. The amount of domestic water used for agricultural purposes will be reduced by 43 MG annually because many farmers and ranchers will be able to convert from the domestic water system to the agricultural water system.		
B. Long-term Productivity	1. Encourages the maintenance of agricultural production on 41,921 acres of farmland by providing a reliable source of agricultural water.	B. Long-term Productivity	1. Commits 34 acres to two reservoir sites and a concrete channel.
C. Energy Requirements and Consumption	1. The amount of gasoline required to pump water will be decreased by 7,100 gallons annually because the stockwater distribution pipeline will be located at a higher elevation than the domestic water system pipeline.	C. Energy Requirements and Consumption	1. The pumping plant will require 550,000 kw-hr of electricity to operate annually under drought conditions.
	2. Creates the potential to install a hydroelectric plant capable of generating 5,800,000 kilowatt-hours(kw-hr) of electricity annually.		
D. Life, Health, and Safety	1. The increased storage capacity of the improved agricultural water system will provide drought security for 176 small farm and ranch units (including 48 native Hawaiian units).	D. Life, Health, and Safety	1. The construction of two reservoirs will increase the risk associated with possible structural failures.
	2. The restoration of Puu Pulehu Reservoir will reduce the risk associated with possible structural failures.		

TABLE II-7a
CAPABILITY OF THE PREFERRED PLAN
Hamakua Area Agricultural Water Study

Problem/ Concern	Objective	Unit	Present Conditions	Future Without Condition	Preferred Plan
INADEQUATE AGRICULTURAL WATER DISTRIBUTION AND SUPPLY	I. DEVELOP AN AGRICULTURAL WATER SYSTEM TO:				
	A. Provide irrigation water for truck crops in:				
	1. Lalamilo farmlots	acres	230	250	250
	2. Lalamilo Agricultural Park	acres	0	0	163
	3. Puukapu and Hawaiian Home Land farmlots	acres	0	0	408
	Total irrigated area	acres	230	250	821
	Water supplied	MG/yr	518	518	1,457
	B. Provide water for sugarcane irrigation:				
	Irrigated sugarcane	acres	0	0	0
	Water supplied	MG/yr	0	0	0
	C. Provide stockwater for pasture areas using the domestic water system and catchments:				
	Pasture area	acres	0	0	31,736
	Stockwater supplied	MG/yr	0	0	52
	D. Provide water to supplement the Parker Ranch stockwater system:				
	Pasture area	acres	0	0	9,188
	Stockwater supplied	MG/yr	0	0	13
	E. Provide water for hay irrigation:				
	Irrigated hay	acres	0	0	176
	Water supplied	MG/yr	0	0	479
	F. Provide adequate storage capacity for all the areas serviced by the system:				
	Storage required	MG	100	100	420
	Storage provided	MG	60	60	350

TABLE II-7b
CAPABILITY OF THE PREFERRED PLAN
Hamakua Area Agricultural Water Study

Problem/Concern	Objective	Unit	Present Conditions	Future Without Conditions	Preferred Plan
INADEQUATE PROTECTION OF LAND AND RELATED WATER RESOURCES	I. PROVIDE NECESSARY ASSOCIATED LAND TREATMENT NEEDS ON AGRICULTURAL LAND				
	Land needing treatment.....	acres	0	40	492
	Land treated.....	acres	0	40	492
	II. PROVIDE NECESSARY ACCELERATED LAND TREATMENT NEEDS ON AGRICULTURAL LAND				
	Land area.....	acres	158,900	158,940	159,432
	Land adequately protected.....	acres	96,960	130,680	134,486
	Land needing treatment.....	acres	61,940	28,260	24,946
MINIMUM STREAM FLOW, HYDROPOWER DEVELOPMENT, AND INCREASED STORAGE CAPACITY	I. MAINTAIN MINIMUM FLOWS IN STREAMS				
	Water bypassed.....	cfs	0	0	1.3
	II. PROVIDE THE POTENTIAL FOR FUTURE HYDROPOWER DEVELOPMENT				
	Energy potential.....	kw-hr	0	0	5,800,000
	III. PROVIDE THE POTENTIAL TO INCREASE THE TOTAL STORAGE CAPACITY OF THE PROPOSED AGRICULTURAL WATER SYSTEM				
	Increased storage potential.....	MG	0	0	230

CHAPTER III
OPPORTUNITIES FOR IMPLEMENTATION

Implementation of the Preferred Plan would require the assistance of federal and/or state agencies. Implementation would also depend on the willingness of the individuals and local organizations involved to initiate requests for assistance and to assume leadership responsibilities.

Technical and financial assistance for implementing the elements of the Preferred Plan could be obtained through various federal and state agencies or programs. Financial assistance could be in the form of direct funding, cost sharing, or loans. Possible sources of assistance are described below and shown in Table III-1.

FEDERAL ASSISTANCE

There are several USDA programs that offer possible sources of technical and/or financial assistance. The use of these programs would depend on the initiative of the sponsors, individual residents and landowners involved. These programs are discussed below.

Public Law 566

Public Law 566, the Watershed Protection and Flood Prevention Act, as amended, provides technical and financial assistance for flood prevention, agricultural water management, recreation, municipal and industrial water supply, fish and wildlife development projects, and watershed protection. The program is administered by the Soil Conservation Service.

Most of the planned elements in the Preferred Plan would be eligible for cost sharing under PL-566. Under this program the federal government could fund up to 50 percent of the construction cost plus the entire cost of engineering services allocated to the irrigation phase of agricultural water management.

Resource Conservation and Development Program

The Resource Conservation and Development (RC&D) Program provides technical and financial assistance to measure sponsors. The program is designed to accelerate the installation of measures through group action or through actions by individuals participating in other USDA programs.

Public Law 46

The Soil Conservation Service, under Public Law 46 the Soil Conservation Act of 1935, develops and carries out a national soil and water conservation program through conservation districts. The SCS, through SWCDs, provides technical assistance to land owners and operators in the planning and application of conservation practices.

Agricultural Conservation Program

The Agricultural Conservation Program (ACP), administered by the Agricultural Stabilization and Conservation Service (ASCS), provides financial assistance to land owners and operators for the installation of conservation practices. This program provides financial assistance in the form of cost sharing, whereby ASCS shares the cost of eligible practices with the participant.

Farmers Home Administration Loan Program

The Farmers Home Administration (FmHA) is authorized to make loans to local sponsors to assist in the implementation of PL-566 and RC&D programs. Loans are used to finance local cost-sharing items.

FmHA also makes soil and water conservation loans and provides financial management assistance to owners and operators of farms and ranches for developing, conserving, and making proper use of their land and water resources.

STATE ASSISTANCE

The Department of Land and Natural Resources (DLNR), Division of Water and Land Development (DOWALD), is the state's water resources and water development agency. The emphasis of the state's water system development program is for agricultural use. Funds for the implementation of eligible plan elements in Table III-1 would be appropriated by the state legislature.

Another possible source of assistance from the state is through the Agricultural Loan Program. The purpose of the program is to promote the agricultural development of the state by making more credit available to qualified farmers. The state Department of Agriculture (DOA) operates the program as a revolving fund which can be used to supplement private and federal funds, or where necessary, make direct loans to farmers.

TABLE III-1
OPPORTUNITIES FOR IMPLEMENTATION
Hamakua Area Agricultural Water Study

Plan Elements	Federal Assistance					State	
	PL-566 Tech./Fin. Assist.	RC&D Fin. Assist.	PL-46 Tech. Assist	ACP Fin. Assist.	FmHA Loan	DLNR	DOA
I. AGRICULTURAL WATER SYSTEM IMPROVEMENTS							
A. COLLECTION SYSTEM							
1. UHD (Repair)	No 1/	No	(Yes)	No	Yes	(Yes)	Yes
2. Concrete Channel	(Yes)	Yes	No	No	Yes	Yes	Yes
3. Flow Regulating Structures	Yes	Yes	(Yes)	No	Yes	(Yes)	Yes
B. RESERVOIR STORAGE SYSTEM							
1. Reservoirs							
a. Puu Ohu	(Yes)	Yes	No	No	Yes	Yes	Yes
b. Regulating	(Yes)	Yes	No	No	Yes	Yes	Yes
c. Puu Pulehu (Rehabilitation)	Yes	Yes	No	No	Yes	(Yes)	Yes
2. Pipeline							
a. 16" DIP	Yes	Yes	No	No	Yes	(Yes)	Yes
b. 21" DIP	(Yes)	Yes	No	No	Yes	Yes	Yes
3. Pumping Plant	Yes	Yes	No	No	Yes	(Yes)	Yes
C. DISTRIBUTION SYSTEM							
1. Truck Crops and Hay							
a. 27" DIP							
(Truck Crops)	(Yes)	Yes	No	No	Yes	Yes	Yes
(Hay)	No	No	No	No	Yes	Yes	Yes
2. Stockwater							
a. 2-6" DIP or PVC	(Yes)	Yes	No	Yes	Yes	Yes	Yes
II. LAND TREATMENT							
A. LAND TREATMENT MEASURES							
1. Associated	Yes	Yes	No	(Yes)	No	Yes	Yes
2. Accelerated	Yes	No	No	Yes	No	Yes	Yes
B. TECHNICAL ASSISTANCE							
1. Associated	Yes	No	(Yes)	No	No	Yes	Yes
2. Accelerated	Yes	No	(Yes)	No	No	Yes	Yes

1/ PL-566 does not apply to maintenance-only type projects.

NOTE: Circles indicate the preferred authorities for assisting local sponsors in implementing plan elements.

Possible cost sharing available:

PL-566, RC&D - Up to 50% of the construction cost plus the entire cost of engineering services allocated to the irrigation phase of agricultural water management.

State - Up to 100% for project installation.

CHAPTER IV
ALTERNATIVE PLANS

FORMULATION OF ALTERNATIVE PLANS

In addition to the Preferred Plan presented in Chapter II, three other alternative plans were formulated: the National Economic Development (NED) Plan, the Environmental Quality (EQ) Plan, and the Primarily Nonstructural Plan. Two co-equal national objectives were used as the basis for the formulation of these plans. The objectives were the protection and enhancement of national economic development, and the protection and enhancement of environmental quality. The alternative plans were formulated to address the problems and concerns of the study in ways that contribute to these two objectives. Each alternative plan consisted of varying degrees of structural and nonstructural measures. Land treatment was also considered in the formulation of the plans.

FORMULATION PROCESS

Throughout the study, a process termed "scoping" was used to insure that all significant decision-making factors were addressed and no unneeded studies were conducted. Because of the numerous variables involved, the formulation and evaluation of all the possible alternatives would have been a substantial undertaking. Therefore, before the alternative plans were formulated, some preliminary work was done to limit the number of variables to be considered.

As part of the preliminary formulation process, 12 "Agricultural Water System Proposals"* were developed to analyze the benefits and costs of supplying water to the various agricultural sectors. Each proposal contained an agricultural water system designed to service a specific sector (sugarcane, truck crops, or livestock) by area or level of supply. For example, five proposals were developed to supply irrigation water to truck crops in Waimea. The systems in each proposal were designed to supply water to irrigate a specific number of acres of truck crops. Each system contained various collection and distribution system components, and in some cases additional reservoir storage components. The "HAAWS Alternative Solutions Report,"* by Kennedy Engineers, provided the preliminary designs and cost estimates for these components. Each component was evaluated for its appropriateness and cost effectiveness to produce a viable system.

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*See Appendix B for a description of the report.

The proposals were "pure" in the sense that each provided water for only one sector by area or level of use. However, the systems were developed so that components from various systems could be combined or modified to develop alternatives capable of servicing more than one sector or area. These systems and their components were used as the building blocks for the alternative plans.

NED Plan Formulation

By definition, the NED Plan maximizes net benefits to national economic development. The "Agricultural Water System Proposals"* determined what agricultural sectors, by area or level of use, could feasibly be supplied with water. The proposals also determined where the water could be used to provide the greatest net economic benefits.

The proposals determined that providing water for truck crops and stock-water use, in certain areas, provided the optimum amount of benefits. Providing water for sugarcane irrigation was determined to be economically unfeasible.

With the determination of the sectors and acres to be serviced, an incremental analysis was conducted to determine the optimum amount of total storage to provide. After the optimum total storage was determined, the appropriate collection and distribution systems were added to form the total agricultural water system included in the NED Plan.

EQ Plan Formulation

The EQ Plan maximizes net contributions to the protection and enhancement of environmental quality. The inadequate protection of land and related water resources was identified as an environmental problem to be addressed by the study. The "HAAWS Land Resources Report"* identified the land treatment needs in the study area and was used to develop the land treatment measures included in the EQ Plan.

The "HAAWS Environmental Impact Assessment,"* prepared by Kennedy Engineers, identified the existing quality and/or quantity of specific resources in the study area. The assessment included an analysis of water quality; fish habitat; wildlife habitat; mineral supply; recreation; the visual quality of the landscape; and unique cultural, historical, and natural sites. The assessment was used to identify other possible EQ concerns that could be addressed by the plan.

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*See Appendix B for a description of the report.

Primarily Nonstructural Plan Formulation

The Primarily Nonstructural Plan employs a minimum of structural measures to address the problems and concerns of the study. The plan has components that contribute to both NED and EQ objectives. The "Agricultural Water System Proposals" provided the structural components included in the plan. The plan also includes land treatment measures from the EQ Plan.

EVALUATION OF ALTERNATIVE PLANS

This section presents the NED, EQ, and Primarily Nonstructural plans in more detail. The elements in each of the alternative plans are described. Each plan was evaluated in terms of its economic, environmental, and social effects; and its capability to address the problems and concerns of the study. A summary of the cost of elements in each alternative plan is shown in Table IV-7. Table IV-8 provides a comparison of the existing and proposed elements in each plan. The effects (Tables IV-9, 10, and 11) and capabilities (Tables IV-12a and b) of each plan are also displayed at the end of this chapter.

Present Conditions and Future Without (FWO) Conditions, as presented in Chapter I, are also presented in some of the tables for comparison purposes. FWO Conditions, forecasted from Present Conditions, served as the basis for evaluating the effects of the alternative plans.

NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

The NED Plan emphasizes maximum net benefits to national economic development. The plan entails improving the agricultural water system to provide water for a total of 821 acres of truck crops under sprinkler irrigation and for stockwater use on 40,924 acres of pasture (Fig. IV-1). The plan also includes associated land treatment measures and technical assistance.

NED Plan Elements

The major elements in the NED Plan are the improvement of the agricultural water system and land treatment. The following sections describe the components in each element. The operation of improved agricultural water system would essentially be the same as described in the Preferred Plan, except that no water would be provided for hay irrigation.

Agricultural Water System Improvements

The NED Plan includes improvements to the Lalamilo Irrigation System's collection, reservoir storage, and distribution systems (Table IV-1).

Collection System Improvements

Collection system improvements include:

- Repairing 9,640 feet of UHD.
- Constructing a concrete channel to divert water from UHD to the proposed reservoir at Puu Ohu.

Reservoir Storage System Improvements

The NED Plan calls for total storage to be increased from 60 MG to 240 MG. An incremental analysis was done to determine the optimum amount of storage to provide. The plan includes:

- Using the existing 60-MG Waimea Reservoir.
- Constructing a 35-MG reservoir at Puu Ohu.
- Constructing a 10-MG Regulating Reservoir.
- Rehabilitating the Puu Pulehu Reservoir to store 135 MG.
- Installing an 18-inch DIP to connect the proposed reservoir at Puu Ohu and the Regulating Reservoir.
- Installing a 16-inch DIP to connect the Waimea and Puu Pulehu Reservoirs.
- Installing a 5,900-gpm pumping plant at the Puu Pulehu Reservoir.

Figure IV-1

NATIONAL ECONOMIC DEVELOPMENT PLAN

HAMAKUA AREA AGRICULTURAL WATER STUDY

ISLAND OF HAWAII

FEBRUARY 1982

1 0 1 2 3 4 5 MILES

SCALE 1:120,000

LEGEND

- Delivery Point
- Pump Station
- Reservoir
- Truck Crops
- Pasture

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OR 1982

7-N-24198-3

TABLE IV-1
STRUCTURAL ELEMENTS AND COSTS - NATIONAL ECONOMIC DEVELOPMENT PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost 1/ Total	Installation Cost 1/ Av. Ann. 2/	O&M 3/	Total Av. Ann. Cost
			dollars			
I. AGRICULTURAL WATER SYSTEM IMPROVEMENTS						
A. COLLECTION SYSTEM						
1. UHD (Repair)	feet	9,640	1,105,000	86,500	5,500	92,000
2. Concrete Channel	feet	5,500	2,813,900	220,100	10,400	230,500
TOTAL (COLLECTION SYSTEM)	-	-	3,918,900	306,600	15,900	322,500
B. RESERVOIR STORAGE SYSTEM						
1. Reservoirs						
a. Puu Ohu	MG	35	2,320,500	181,600	1,800	183,400
Truck Crops	MG	(30) 4/	(1,988,700)	(155,600)	(1,500)	(157,100)
Stockwater	MG	(5)	(331,800)	(26,000)	(300)	(26,300)
b. Regulating	MG	10	651,900	51,000	600	51,600
c. Puu Pulehu (Rehabilitation)	MG	135	866,200	67,800	7,200	75,000
Subtotal (Reservoirs)	MG	180	3,838,600	300,400	9,600	310,000
2. Pipeline						
a. 16" DIP	feet	15,200	1,648,800	129,000	12,000	141,000
b. 18" DIP	feet	9,500	1,951,400	152,700	11,800	164,500
3. Pumping Plant	gpm	5,900	402,000	31,400	14,800	46,200
TOTAL (RESERVOIR STORAGE SYSTEM)	-	-	7,840,800	613,500	48,200	661,700
C. DISTRIBUTION SYSTEM						
1. Truck Crops						
a. 24" DIP	feet	5,000	853,100	66,700	3,900	70,600
2. Stockwater						
a. 2-6" DIP or PVC	feet	101,500	3,370,100	263,700	12,000	275,700
TOTAL (DISTRIBUTION SYSTEM)	-	-	4,223,200	330,400	15,900	346,300
TOTAL (WATER SYSTEM IMPROVEMENTS)	-	-	15,982,900	1,250,500	80,000	1,330,500

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Figures in ( )'s not included in totals.

Distribution System Improvements

Improvements to the truck crops distribution system include:

- Installing a 24-inch DIP to connect the Regulating Reservoir to the existing 24-inch DIP in Kuhio Village.

- Using the existing 18- and 24-inch DIP to distribute water to the Lalamilo farmlots and the proposed Lalamilo Agricultural Park - Phase I development.

- Allowing HHL and Puukapu farmers to hook up their on-farm irrigation systems to the 24-inch DIP.

This system would have the capacity to supply a peak of 12.6 MGD and 1,457 MG annually for the irrigation of 821 acres of truck crops.

Improvements to the stockwater distribution system include:

- Installing 101,500 feet of DIP and PVC pipeline varying from 2 to 6 inches in diameter.

The stockwater pipeline would be connected to the proposed 18-inch DIP between the Puu Ohu and Regulating reservoirs. The alignment of the pipeline would be the same as described in the Preferred Plan.

This distribution system would have the capacity to supply a peak flow of .42 MGD and 65 MG annually for stockwater use on 40,924 acres of pasture.

Land Treatment

The NED Plan includes associated land treatment measures, plus the technical assistance required to plan and apply these measures. These measures would benefit 316 acres of truck crop land (Table IV-2).

TABLE IV-2
LAND TREATMENT - NATIONAL ECONOMIC DEVELOPMENT PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost 1/ Total	Installation Cost 1/ Av. Ann. 2/	O&M 3/	Total Av. Ann. Cost
			dollars			
I. ASSOCIATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres 4/	316	126,400	9,900	0	9,900
B. Technical Assistance..	person-years	.28	5,900		0	500
TOTAL (ASSOCIATED).....	-	-	132,300	10,400	0	10,400

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Acres benefited.

NED Plan Effects

NED Account

Beneficial Effects

Beneficial NED effects are attributable to the value of the increased output of goods and services that would be generated by the NED Plan. The effects were measured as the increase in net income (gross income minus production costs) received by producers with the plan, compared to net income without the plan. The improved agricultural water system would increase the net income from agricultural production by:

- Providing water for an additional 163 acres of irrigated truck crops in the proposed Lalamilo Agricultural Park.

- Allowing the Puukapu and HHL farmers to convert from the domestic to the agricultural water system. They would be able to irrigate a total of 408 acres of truck crops, which includes 255 existing acres and 153 additional acres.

- Providing water for livestock use on 40,924 acres of pasture that are using water from the domestic system, Parker Ranch system, and/or catchments.

Another beneficial effect would be the reduction of operation and maintenance costs for the Lalamilo Irrigation System due to the repair of UHD.

Total average annual beneficial effects are an estimated $2,248,300 (Table IV-9).

Adverse Effects

Adverse NED effects were attributable to the cost of the resources required to implement the NED Plan. Total average annual adverse effects are an estimated $1,340,900.

Net Effects

Total average annual net beneficial effects are $907,400. The benefit cost ratio is 1.68:1.

EQ Account

The beneficial and adverse environmental quality effects of the NED Plan are shown in Table IV-10.

OSE Account

The effects in the OSE account were evaluated in the following categories: urban and community impacts; long-term productivity; energy requirements and consumption; and life, health, and safety (Table IV-11).

Capability of the NED Plan

The capability of the NED Plan to address the problems and concerns of the study is shown in Tables IV-12a and b.

ENVIRONMENTAL QUALITY (EQ) PLAN

The EQ Plan emphasizes maximum net benefits to environmental quality. The plan includes minimal agricultural water system improvements and the installation of accelerated land treatment measures in the study area.

EQ Plan Elements

The major elements in the EQ Plan are the improvement of the agricultural water system and land treatment. The following sections describe the components in each element.

Agricultural Water System Improvements

The EQ Plan includes improvements to the Lalamilo Irrigation System's collection system (Table IV-3). The system's reservoir storage and distribution systems would be utilized as is. The system would continue to service only the Lalamilo farmlots.

Collection System Improvements

- Repairing 9,640 feet of the UHD.

- Installing 5 flow regulating structures at the Kawainui, Kawaiki, Alakahi, Koiawe, and Waima stream intakes.

TABLE IV-3
STRUCTURAL ELEMENTS AND COSTS - ENVIRONMENTAL QUALITY PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost 1/ Total	Installation Cost 1/ Av. Ann. 2/	O&M 3/	Total Av. Ann. Cost
			dollars			
1. AGRICULTURAL WATER SYSTEM IMPROVEMENTS						
A. COLLECTION SYSTEM						
1. UHD (repair).....	feet	9,640	1,105,000	86,500	5,500	92,000
2. Flow Regulating Structures.....	number	5	184,500	14,400	900	15,300
TOTAL (WATER SYSTEM IMPROVEMENTS)	-	-	1,289,500	100,900	6,400	107,300

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.

Land Treatment

The EQ Plan includes the accelerated land treatment necessary to adequately protect the land and related water resources of the study area. Accelerated land treatment includes land treatment measures that are needed over and above what is currently being applied as part of the ongoing conservation program.

The plan would provide accelerated land treatment that would benefit a total of 28,260 acres of agricultural land (Table IV-4).

Land treatment measures, practices, and management systems for the truck crop land include:

- Field windbreaks.
- Grassed waterways.
- Terrace systems.
- Diversions.
- Conservation cropping systems.*
- Conservation tillage systems.*
- Crop residue use.
- Contour farming.*
- Cover and green manure crops.
- Irrigation water management.*
- Conservation plans.*

Land treatment for the sugarcane land include:

- Conservation cropping systems.*
- Crop residue use.
- Proper field road design and maintenance.
- Cross slope farming.*
- Critical area planting.
- Alternate block harvest.*

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*Items require technical assistance only.

- Diversions.

- Terrace systems.

- Grassed waterways.

Land treatment for pasture land include:

- Pasture management.

- Planned grazing systems.*

- Proper grazing use.*

- Fencing.

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*Items require technical assistance only.

TABLE IV-4
LAND TREATMENT - ENVIRONMENTAL QUALITY PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost 1/ Total	Installation Cost 1/ Av. Ann. 2/	O&M 3/	Total Av. Ann. Cost
			dollars			
I. ACCELERATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres 4/	120	68,600	5,400	500	5,900
2. Sugarcane.....	acres 4/	18,520	8,335,500	652,200	190,600	842,800
3. Pasture.....	acres 4/	9,620	2,953,300	231,000	122,200	353,200
SUBTOTAL.....	acres 4/	28,260	11,357,400	888,600	313,300	1,201,900
B. Technical Assistance....	person-years	3.31	68,800	5,400	0	5,400
TOTAL (ACCELERATED).....	-	-	11,426,200	894,000	313,300	1,207,300

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Acres benefited.

EQ Plan Effects

NED Account

Beneficial Effects

A beneficial effect of the EQ Plan would be the reduction of operation and maintenance costs for the Lalamilo Irrigation System due to the repair of UHD.

The beneficial effects of land treatment on agricultural production could not be measured in a sound manner and therefore were not evaluated.

Total average annual beneficial effects are an estimated $100,000.

Adverse Effects

Total average annual adverse effects are an estimated $107,300 (Table IV-9).

Net Effects

Total average annual net beneficial effects are $7,300. The benefit cost ratio is .93:1.

EQ Account

The beneficial and adverse environmental quality effects of the EQ Plan are shown in Table IV-10.

OSE Account

The effects in the OSE account were evaluated in the following categories: urban and community impacts; long-term productivity; energy requirements and consumption; and life, health, and safety (Table IV-11).

Capability of the EQ Plan

The capability of the EQ Plan to address the problems and concerns of the study is shown in Tables IV-12a and b.

PRIMARILY NONSTRUCTURAL PLAN

The Primarily Nonstructural Plan emphasizes the use of a minimum amount of structural elements to address the problems and concerns of the study. The plan entails making minimal improvements to the agricultural water system and maximizing the use of the available water resources. The improved system would provide water for a total of 668 acres of truck crops under sprinkler irrigation (Fig. IV-2). The plan also includes the land treatment measures necessary to adequately protect the soil and related water resources in the area serviced by the system.

Primarily Nonstructural Plan Elements

The major elements in the Primarily Nonstructural Plan are the improvement of the agricultural water system and land treatment. The following sections describe the components in each element. The operation of the improved irrigation system is also described.

Agricultural Water System Improvements

The Primarily Nonstructural Plan includes improvements to the Lalamilo Irrigation System's collection, reservoir storage, and distribution systems (Table IV-5).

Collection System Improvements

- Repairing 9,640 feet of the UHD.

Reservoir Storage System Improvements

The plan calls for total storage to be increased from 60 MG to 195 MG and includes:

- Using the existing 60-MG Waimea Reservoir.
- Rehabilitating the Puu Pulehu Reservoir to store 135 MG.
- Installing a 16-inch DIP to connect both reservoirs.
- Installing a 5,900-gpm pumping plant at the Puu Pulehu Reservoir.

Distribution System Improvements

Improvements to the truck crops distribution system include:

- Using the existing 18- and 24-inch DIP to distribute water to the Lalamilo farmlots and the proposed Lalamilo Agricultural Park - Phase I development.
- Allowing HHL and Puukapu farmers to hook up their on-farm irrigation systems to the 24-inch DIP.

This system would have the capacity to supply a peak flow of 12.4 MGD and 1,234 MG annually for 668 acres of irrigated truck crops.

TABLE IV-5
STRUCTURAL ELEMENTS AND COSTS - PRIMARILY NONSTRUCTURAL PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation cost 1/ Total	Av. Ann. 2/	O&M 3/	Total Av. Ann. Cost
			dollars			
I. AGRICULTURAL WATER SYSTEM IMPROVEMENTS						
A. COLLECTION SYSTEM						
1. UHD (repair).....	feet	9,640	1,105,000	86,500	5,500	92,000
B. RESERVOIR STORAGE SYSTEM						
1. Puu Pulehu.....	MG	135	866,200	67,800	7,200	75,000
2. 16" DIP.....	feet	15,200	1,648,800	129,000	12,000	141,000
3. Pumping Plant.....	gpm	5,900	402,000	31,400	14,800	46,200
TOTAL (RESERVOIR STORAGE SYSTEM)	-	-	2,917,000	228,200	31,200	259,400
TOTAL (WATER SYSTEM IMPROVEMENTS)	-	-	4,022,000	314,700	39,500	354,200

1/ 1981 price base
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.

System Operation

The improved irrigation system would operate variably, according to the inflow of water and the water supply available from the system's two reservoirs.

High or Normal Inflow

During the high or normal inflow periods, the Waimea Reservoir would serve as the source of water for all the irrigated truck crop areas. Overflow from Waimea would be conveyed via the proposed 16-inch DIP to the Puu Pulehu Reservoir for storage.

Low or No Inflow

During periods of low or no inflow, water from the Puu Pulehu Reservoir would be pumped to refill the Waimea Reservoir or pumped directly to the truck crop areas.

Figure IV-2

PRIMARILY NONSTRUCTURAL PLAN

HAMAKUA AREA AGRICULTURAL WATER STUDY

ISLAND OF HAWAII

FEBRUARY 1982

SCALE 1:120,000

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA SCS PORTLAND OR 1982

Land Treatment

The Primarily Nonstructural Plan includes associated and accelerated land treatment measures for the areas serviced by the improved agricultural water system proposed by the plan. The plan provides associated land treatment for 163 acres of cropland and accelerated land treatment that would benefit 264 acres of cropland (Table IV-6).

TABLE IV-6
LAND TREATMENT - PRIMARILY NONSTRUCTURAL PLAN
Hamakua Area Agricultural Water Study

Element/Component	Unit	Amount	Installation Cost[1/] Total	Installation Cost[1/] Av. Ann.[2/]	O&M[3/]	Total Av. Ann. Cost
			dollars			
I. ASSOCIATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres[4/]	163	65,200	5,100	0	5,100
B. Technical Assistance...	person-years	.14	3,000	200	0	200
TOTAL (ASSOCIATED).....	-	-	68,200	5,300	0	5,300
II. ACCELERATED LAND TREATMENT						
A. Measures						
1. Truck Crops.....	acres[4/]	264	150,900	11,800	1,100	12,900
B. Technical Assistance...	person-years	1.27	26,400	2,100	0	2,100
TOTAL (ACCELERATED).....	-	-	177,300	13,900	1,100	15,000

1/ 1981 price base.
2/ Total installation cost amortized at 7 5/8% interest for 50 years.
3/ Annual operation and maintenance cost.
4/ Acres benefited.

Primarily Nonstructural Plan Effects

NED Account

Beneficial Effects

Beneficial NED effects are attributable to the value of the increased output of goods and services that would be generated by the Primarily Nonstructural Plan. The effects were measured as the increase in net income (gross income minus production costs) received by producers with the plan, compared to net income without the plan. The improved agricultural water system would increase the net income from agricultural production by:

- Providing water for an additional 163 acres of irrigated truck crops in the proposed Lalamilo Agricultural Park.

- Allowing the Puukapu and HHL farmers to convert from the domestic to the agricultural water system. They would be able to irrigate 255 acres of truck crops.

Another beneficial effect would be the reduction of operation and maintenance costs for the Lalamilo Irrigation System due to the repair of UHD.

Total average annual beneficial effects are an estimated $473,700. (Table IV-9).

Adverse Effects

Total average annual adverse effects are an estimated $359,500.

Net Effects

Total average annual net beneficial effects are $114,200. The benefit cost ratio is $1.32:1.

EQ Account

The beneficial and adverse environmental quality effects of the Primarily Nonstructural Plan are shown in Table IV-10.

OSE Account

The effects in the OSE account were evaluated in the following categories: urban and community impacts; long-term productivity; energy requirements and consumption; and life, health, and safety (Table IV-11).

Capability of the Primarily Nonstructural Plan

The capability of the Primarily Nonstructural Plan to address the problems and concerns of the study is shown in Tables IV-12a and b.

TABLE IV-7
SUMMARY OF ELEMENTS AND COSTS - ALTERNATIVE PLANS
Hamakua Area Agricultural Water Study

Element/Component	National Economic Development Plan[1/]	Environmental Quality Plan[2/]	Primarily Nonstructural Plan[3/]	Preferred Plan[4/]
	(total installation cost)			
I. AGRICULTURAL WATER SYSTEM IMPROVEMENTS				
A. Cropland (Truck Crops and Hay)				
1. Collection System	$ 3,918,900	$ 1,289,500	$1,105,000	$ 4,029,400
2. Reservoir Storage System	7,509,000	0	2,917,000	12,405,900
3. Distribution System	853,100	0	0	1,120,500
SUBTOTAL	$12,281,000	$ 1,289,500	$4,022,000	$17,555,800
B. Stockwater				
1. Reservoir Storage System	$ 331,800	$ 0	$ 0	$ 231,000
2. Distribution System	3,370,100	0	0	3,370,100
SUBTOTAL	$ 3,701,900	$ 0	$ 0	$ 3,601,100
TOTAL (WATER SYSTEM IMPROVEMENTS)	$15,982,900	$ 1,289,500	$4,022,000	$21,156,900
II. LAND TREATMENT				
A. Associated Land Treatment	$ 132,300	$ 0	$ 68,200	$ 205,900
B. Accelerated Land Treatment	0	(11,426,200)[5/]	(177,300)[5/]	(1,389,600)[5/]
TOTAL (LAND TREATMENT)	$ 132,300	$ 0	$ 68,200	$ 205,900
GRAND TOTAL (ALL ELEMENTS/COMPONENTS)	$16,152,200	$ 1,289,500	$4,090,200	$21,362,800
AVERAGE ANNUAL COST[6/]	$ 1,340,900	$ 107,300	$ 359,500	$ 1,760,100

1/ From Tables IV-1 and IV-2.
2/ From Tables IV-3 and IV-4.
3/ From Tables IV-5 and IV-6.
4/ From Tables II-2 and II-3.
5/ Accelerated land treatment not charged as a cost to the plan.
6/ Includes annual operation and maintenance cost.

TABLE IV-8
COMPARISON OF EXISTING AND PROPOSED ELEMENTS
Hamakua Area Agricultural Water Study

Element	Unit	Present & Future Without	NED Plan	Primarily Nonstructural Plan	EQ Plan	Preferred Plan
I. AGRICULTURAL WATER SYSTEM IMPROVEMENTS						
A. COLLECTION SYSTEM						
1. UHD[1/]	feet	(35,850)	(35,850)	(35,850)	(35,850)	(35,850)
2. UHD (Repair)	feet	-	9,640	9,640	9,640	9,640
3. Concrete Channel	feet	-	5,500	-	-	5,500
4. Flow Regulating Structures (Replace)	number	(5)	-	-	5	3
B. RESERVOIR STORAGE SYSTEM						
1. Reservoirs						
a. Waimea[1/]	MG	(60)	(60)	(60)	(60)	(60)
b. Puu Ohu	MG	-	35	-	-	145
c. Regulating	MG	-	10	-	-	10
d. Puu Pulehu (Rehabilitation)	MG	-	135	135	-	135
Subtotal (Reservoirs)	MG	(60)	240	195	(60)	350
2. Pipeline						
a. 16" DIP	feet	-	15,200	15,200	-	15,200
b. 18" DIP	feet	-	9,500	-	-	-
c. 21" DIP	feet	-	-	-	-	9,500
3. Pumping Plant	gpm	-	5,900	5,900	-	5,900
C. DISTRIBUTION SYSTEM						
1. Truck Crops and Hay						
a. 18" DIP[1/]	feet	(10,500)	(10,500)	(10,500)	(10,500)	(10,500)
b. 24" DIP[1/]	feet	(19,350)	(19,350)	(19,350)	(19,350)	(19,350)
c. 24" DIP	feet	-	5,000	-	-	-
d. 27" DIP	feet	-	-	-	-	5,000
2. Stockwater						
a. 2-6" DIP or PVC pipeline	feet	-	101,500	-	-	101,500
II. LAND TREATMENT						
A. ASSOCIATED LAND TREATMENT	acres	40	316	163	0	492
B. ACCELERATED LAND TREATMENT	acres	0	0	264	28,260	3,806

1/ Existing facilities which would remain in each alternative plan shown in parentheses.

TABLE IV-9
EFFECTS OF ALTERNATIVE PLANS
NATIONAL ECONOMIC DEVELOPMENT ACCOUNT
Hamakua Area Agricultural Water Study

Effects	Average Annual	Future Without Conditions	NED Plan	EQ Plan	Primarily Nonstructural Plan	Preferred Plan
NED ACCOUNT						
I. Beneficial Effects						
A. Value to Users of Increased Output of Goods and Services:[1]						
1. Irrigation - Cropland	dollars	132,600	1,876,900	0	373,700	1,865,100
2. Stockwater - Pasture and Livestock	dollars	0	271,400	0	0	267,200
3. Reduction in O&M	dollars	0	100,000	100,000	100,000	100,000
TOTAL BENEFICIAL EFFECTS	dollars	132,600	2,248,300	100,000	473,700	2,232,300
II. Adverse Effects						
A. Value of Resources Required:						
1. Plan Outlays[1] [2]						
a. Agricultural Water System Improvements						
(1) Irrigation - Cropland	dollars	100,000	1,028,500	107,300	354,200	1,449,900
(2) Stockwater - Pasture and Livestock	dollars	0	302,000	0	0	294,100
b. Associated Land Treatment	dollars	1,300	10,400	0	5,300	16,100
c. Accelerated Land Treatment	dollars	0	0	(1,207,300)[3]	(15,000)[3]	(151,900)[3]
TOTAL ADVERSE EFFECTS	dollars	101,300	1,340,900	107,300	359,500	1,760,100
III. NET BENEFICIAL EFFECTS[4]	dollars	-	907,400	7,300	114,200	472,200
IV. BENEFIT/COST RATIO[5]	-	-	1.68:1	.93:1	1.32:1	1.27:1

1/ 1981 price base.
2/ Amortized at 7 5/8% interest for 50 years.
3/ Accelerated land treatment costs not charged against NED beneficial effects.
4/ Total beneficial effects minus total adverse effects.
5/ Total beneficial effects divided by total adverse effects.

TABLE IV-10
EFFECTS OF ALTERNATIVE PLANS
ENVIRONMENTAL QUALITY ACCOUNT
Hamakua Area Agricultural Water Study

Effects	Unit	Future Without Conditions	NED Plan	EQ Plan	Primarily Nonstructural Plan	Preferred Plan
EQ ACCOUNT			(in comparison to Future Without Conditions)			
A. Ecological Attributes						
1. Beneficial Effects						
a. Low Stream Flow Bypassed.....	cfs	0	0	+1.7	0	+1.3
b. Reduced Sedimentation due to Accelerated Land Treatment.....	yes/no	no	no	yes	yes	yes
2. Adverse Effects						
a. Upland Wildlife Habitat Lost.....	acres	0	+18	0	0	+ 34
B. Aesthetic Attributes						
1. Beneficial Effects						
a. Additional Areas of Color Contrast	acres	0	+316	0	0	+492
b. Reservoirs Rehabilitated.....	number	0	+ 1	0	0	+ 1
c. Water Surface Area.....	acres	55	+ 15	0	0	+ 30
2. Adverse Effects						
a. Landscape Temporarily Disturbed...	yes/no	no	yes	no	yes	yes
b. Rural Environment Temporarily Disrupted.....	yes/no	no	yes	no	yes	yes
C. Cultural Attributes						
1. Beneficial Effects						
a. Identifies Archeological and Historic Sites.....	yes/no	no	yes	yes	yes	yes
2. Adverse Effects						
a. Potential Disturbance of Unknown Archeological Sites.....	yes/no	no	yes	no	no	yes

TABLE IV-11
EFFECTS OF ALTERNATIVE PLANS
OTHER SOCIAL EFFECTS ACCOUNT
Hamakua Area Agricultural Water Study

Effects	Unit	Future Without Conditions	NED Plan	EQ Plan	Primarily Nonstructural Plan	Preferred Plan
			(increase over Future Without Conditions)			
OSE ACCOUNT						
A. Urban and Community Impacts						
1. Positive Effects						
a. New Agricultural Jobs	number	0	160	0	85	165
b. On-farm Technical Assistance	person-years	.8	.28	3.31	1.41	3.57
c. Small Farm and Ranch Units with Agricultural Water Supply	number	28	152	0	65	152
(Native Hawaiian Units)	(number)	(0)	(48)	0	(11)	(48)
d. Domestic Water Used for Agriculture	MG	43	-43	0	-30	-43
B. Long-term Productivity						
1. Positive Effects						
a. Agricultural Lands Maintained	acres	0	41,745	0	1,710	41,921
2. Negative Effects						
a. Upland Wildlife Habitat Lost	acres	0	18	0	0	34
C. Energy Requirements and Consumption						
1. Positive Effects						
a. Gasoline Required for Pumping Water	gallons	30,000	-7,100	0	0	-7,100
b. Future Hydropower Development Potential	kw-hr	0	4,300,000	0	0	5,800,000
2. Negative Effects						
a. Energy Required to Operate Pumping Plant	kw-hr	0	550,000	0	550,000	550,000
D. Life, Health, and Safety						
1. Beneficial Effects						
a. Small Farm and Ranch Units Provided Drought Security	number	0	176	0	93	176
(Native Hawaiian Units)	(number)	(0)	(48)	(0)	(11)	(48)
b. Reservoirs Rehabilitated	number	0	1	0	0	1
2. Adverse Effects						
a. Reservoirs Constructed	number	0	2	0	0	2

TABLE IV-12a
CAPABILITY OF ALTERNATIVE PLANS
Hamakua Area Agricultural Water Study

Problem/ Concern	Objective	Unit	Present Conditions	Future Without Conditions	NED Plan	EQ Plan	Primarily Nonstructural Plan	Preferred Plan
INADEQUATE AGRICULTURAL WATER DISTRIBUTION AND SUPPLY	1. DEVELOP AN AGRICULTURAL WATER SYSTEM TO:							
	A. Provide irrigation water for truck crops in the:							
	1. Lalamilo farmlots.....	acres	230	250	250	250	250	250
	2. Lalamilo Agricultural Park....	acres	0	0	163	0	163	163
	3. Puukapu and Hawaiian Home Land farmlots.....	acres	0	0	408	0	255	408
	Total irrigated area.....	acres	230	250	821	250	668	821
	Water supplied.....	MG/yr	518	518	1,457	518	1,234	1,457
	B. Provide water for sugarcane irrigation:							
	Irrigated sugarcane.....	acres	0	0	0	0	0	0
	Water supplied.....	MG/yr	0	0	0	0	0	0
	C. Provide stockwater for pasture areas using the domestic water system:							
	Pasture area.....	acres	0	0	31,736	0	0	31,736
	Stockwater supplied.....	MG/yr	0	0	52	0	0	52
	D. Provide water to supplement the Parker Ranch stockwater system:							
	Pasture area.....	acres	0	0	9,188	0	0	9,188
	Stockwater supplied.....	MG/yr	0	0	13	0	0	13
	E. Provide water for hay irrigation:							
	Irrigated hay.....	acres	0	0	0	0	0	176
	Water supplied.....	MG/yr	0	0	0	0	0	479
	F. Provide adequate storage capacity for all the areas serviced by the system:							
	Storage required.....	MG	100	100	270	100	195	420
	Storage provided.....	MG	60	60	240	60	195	350

1/ Varies with condition or alternative.

TABLE IV-12b
CAPABILITY OF ALTERNATIVE PLANS
Hamakua Area Agricultural Water Study

Problem/Concern	Objective	Unit	Present Conditions	Future Without Conditions	NED Plan	EQ Plan	Primarily Nonstructural Plan	Preferred Plan
INADEQUATE PROTECTION OF LAND AND RELATED WATER RESOURCES	I. PROVIDE NECESSARY ASSOCIATED LAND TREATMENT NEEDS ON AGRICULTURAL LAND							
	Area requiring treatment.....	acres	0	40	316	0	163	492
	Area treated.....	acres	0	40	316	0	163	492
	II. PROVIDE NECESSARY ACCELERATED LAND TREATMENT NEEDS ON AGRICULTURAL LAND							
	Land area.....	acres	158,900	158,940	159,256	158,940	159,103	159,432
	Land adequately protected.....	acres	96,960	130,680	130,680	158,940	130,944	134,486
	Land needing treatment.....	acres	61,940	28,260	28,260	0	28,159	24,946
MINIMUM STREAM FLOW, HYDROPOWER DEVELOPMENT, AND INCREASED STORAGE CAPACITY	I. MAINTAIN MINIMUM FLOWS IN STREAMS							
	Water bypassed.....	cfs	1/	0	0	1.7	0	1.3
	II. PROVIDE THE POTENTIAL FOR FUTURE HYDROPOWER DEVELOPMENT							
	Energy potential.....	kw-hr	2/	0	4,300,000	0	0	5,800,000
	III. PROVIDE THE POTENTIAL TO INCREASE THE TOTAL STORAGE CAPACITY OF THE PROPOSED AGRICULTURAL WATER SYSTEM							
	Increased storage potential.....	MG	2/	0	340	0	0	230

1/ Varies with condition or plan.
2/ Not specified.

APPENDIXES

APPENDIX A
RESOURCE BASE DATA

Study Name: Hamakua Area Agricultural Water Study (HAAWS.

Size of Study Area: 211,660 acres.

Location: Northern part of the Island of Hawaii (Fig. 1).

Climate: Average annual temperatures range from 75°F along the coastline to 40°F on the upper slopes of Mauna Kea. Temperatures fluctuate very little throughout the year.

Rainfall: Average annual rainfall along the Hamakua Coast goes from 60 inches along the coastline to 100 inches at elevation 2,500 feet, then decreases thereon up the slopes of Mauna Kea. Rainfall in the Waimea area varies from 20 inches in the plains to 175 inches in the Kohala Mountains.

Land Ownership:

Landowner	Acres	Percent
State of Hawaii	43,350	20.5
Department of Hawaiian Home Lands	32,570	15.4
Parker Ranch	46,000	21.7
Davies-Hamakua Sugar Company	32,000	15.7
Other - Private	57,740	26.7
Total	211,660	100.0

Land Use:

Land Use	Total Acres	Percent	Irrigated Acres
Pasture	122,620	57.9	0
Sugarcane	35,720	16.9	6,895
Truck Crops	1,400	.7	560
Orchards	1,190	.6	20
Forest	22,740	10.7	0
Urban	1,840	.9	0
Miscellaneous	26,150	12.3	0
Total	211,660	100	7,475

Major Industries: The major industry of the study area is sugarcane growing and processing, followed by the livestock, and truck crop production.

Population: 12,600

APPENDIX B

SPECIAL HAAWS REPORTS

Name of Report*	Prepared By**	Subject Matter
1. HAAWS Plan of Work	SCS, ERS, FS	Phases of the study, schedule of major activities, work outline for specialists or agencies.
2. HAAWS Economic Base Report	SCS	Population characteristics, labor force and employment, agricultural industries.
3. HAAWS Environmental Impact Assessment	KE	Water quality; fish and wildlife habitat; mineral supply; recreation quality of the landscape; unique, cultural, and historic sites.
4. HAAWS Forest Resources Report	FS	Forest resources and use, forest plantation establishment potential.
5. HAAWS Land Resources Report	SCS	Land ownership and use, soil suitability, land resource problems, land resource development potential.
6. HAAWS Water Resources Report	SCS	Surface and ground water resources, existing water distribution systems, water quality.
7. HAAWS Water Use Inventory Report	SCS	Present water use, potential water demand, water development needs.
8. HAAWS Alternative Solutions Report	KE	Agricultural water system structural components, design considerations, and cost data; hydroelectric power.
9. HAAWS Agricultural Water System Proposals	SCS	Possible agricultural water systems to service different areas.

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*Copies available for review at Soil Conservation Service, Room 4316 Prince Kuhio Federal Building, 300 Ala Moana Blvd., Honolulu, HI 96850.

**SCS = Soil Conservation Service
ERS = Economic Research Service
FS = Forest Service
KE = Kennedy Engineers, Honolulu, Hawaii (by SCS contract)